NORTHERN DRAINAGE PERCHLORATE SAMPLING RESULTS
TECHNICAL MEMORANDUM
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VENTURA COUNTY, CALIFORNIA

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November 2003

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ACRONYMS

AOC	Area of Concern
bgs	below ground surface
Boeing	The Boeing Company
Cal/EPA	California Environmental Protection Agency
Ceimic	Ceimic Laboratory
Del Mar	Del Mar Laboratories
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
^{2}H	deuterium
EPA	United States Environmental Protection Agency
IEL	Instrument and Equipment Laboratory
HVIM	Happy Valley Interim Measures
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MWL	meteoric water line
mg/L	milligrams per liter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
NASA	National Aeronautics and Space Administration
^{18}O	oxygen isotope
RCRA	Resource Conservation Recovery Act
RFI	RCRA Facility Investigation
SSFL	Santa Susana Field Laboratory
STL	Severn Trent Laboratory
SWMU	Solid Waste Management Unit
TDS	total dissolved solids

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EXECUTIVE SUMMARY

Boeing sampled surficial media within the Northern Drainage based on conflicting and questionable perchlorate groundwater sample results from offsite well OS-9. Sediment and surface water sampling was performed to test perchlorate migration via the surface water pathway, and spring/seep sampling was performed to test perchlorate migration via the groundwater pathway. Samples were collected both on- and offsite, and analyzed for perchlorate. Surface water and spring/seep samples were also analyzed for stable hydrogen and oxygen isotopes, anions, and total dissolved solids to assess general water quality conditions and to evaluate the source of water at these locations. Results of the Northern Drainage sampling program are:

- A total of 171 samples were collected from 79 locations over a distance of about 3 miles
- Perchlorate was not detected in any of the 71 offsite samples
- All 140 sediment leachate samples were non detect, with one possible exception in the upper portion of the drainage near the base of the Area I Landfill
  - ➢ This sample had a reported concentration of 3.6 µg/L (estimated below the laboratory reporting limit)
  - ➢ Resampling at this location did not detect perchlorate
  - ➢ 137 sediment leachate samples were located downstream of this location; perchlorate was not detected in any downstream sample
- All 14 surface water samples were non detect for perchlorate
  - ➢ The source of water at 4 of 6 surface water locations was groundwater
- All 15 spring/seep and 2 associated rock chip samples were non detect for perchlorate
  - ➢ The source of water at 7 of 8 spring/seep locations was groundwater; one was a mixture of groundwater and surface water

Therefore, the following conclusions are made:

1) Sediment and surface water data collected during this program indicate that perchlorate has not been transported offsite via the surface water pathway within the Northern Drainage.

2) The spring/seep data collected during this program, coupled with other groundwater data presented in the Perchlorate Characterization Work Plan (MWH 2003f), indicate that perchlorate has not been transported offsite via the groundwater pathway to the Northern Drainage area. Additional testing of the groundwater pathway is in progress or planned to further evaluate this conclusion.

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1.0 INTRODUCTION

This technical memorandum presents the results of field sampling activities and analytical testing of drainage sediment, surface water, and springs/seeps along and within the Northern Drainage of the Santa Susana Field Laboratory (SSFL) for perchlorate characterization. The SSFL is located in the Simi Hills approximately 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County (Figure 1). The SSFL is jointly owned by The Boeing Company (Boeing) and the National Aeronautics and Space Administration (NASA), and is operated by Boeing. A portion of the SSFL owned by Boeing is occupied by the United States Department of Energy (DOE) facilities that are undergoing closure. This technical memorandum has been prepared by MWH on behalf of Boeing.

Environmental investigation at the SSFL is being conducted as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action Program, under the oversight and jurisdiction of the California Environmental Protection Agency (Cal-EPA) Department of Toxic Substances Control (DTSC). The RCRA program at the SSFL is currently in the RCRA Facility Investigation (RFI) phase. Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) identified at the SSFL undergoing closure as part of the RFI program have been grouped by location, and are shown as 50 RFI sites on Figure 2. The site investigation is being conducted under DTSC-approved work plans (Ogden 1996, 2000a, and 2000b). Perchlorate sampling has been conducted at and near these RFI sites as described in the Perchlorate Source Evaluation and Technical Report (MWH 2003a), and in the Happy Valley Interim Measure (HVIM) Work Plan (MWH 2003e).

1.1 PROJECT BACKGROUND

Boeing initiated the Northern Drainage sampling program because conflicting and questionable perchlorate sampling results were reported from offsite well OS-9 (also known as Bathtub Well #1). OS-9 is an artesian well located just over 1 mile north of the SSFL on Brandies-Bardin property. Perchlorate was reportedly detected in 4 of 6 samples collected by DTSC from OS-9 on May 30 and June 11, 2003. The two May 30 samples were analyzed at American Technologies Laboratory (ATL), and reportedly contained 140 and 150 micrograms

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per liter (µg/L) perchlorate. On June 11 DTSC collected four additional samples. Two of these were analyzed at the DTSC laboratory and were reported to not contain perchlorate. The other two samples were analyzed at ATL and were reported to contain 36 and 39 µg/L perchlorate.

Based on these conflicting results, Boeing initiated a comprehensive sampling program on July 1, 2003 in the drainage leading to OS-9. The sampling began coincident with preparation of a work plan detailing the characterization activities because the opportunity to collect some samples would be missed if the program was delayed (i.e., surface water pools or spring/seeps might be dry).

In August 2003, a Perchlorate Characterization Work Plan (MWH 2003d) was prepared and submitted to DTSC. This work plan outlined the tasks to be performed to evaluate the potential offsite migration of perchlorate from the SSFL. (Based on DTSC comments, this work plan is being revised [MWH 2003f].) Activities described in the Perchlorate Characterization Work Plan include collecting and analyzing samples of drainage sediment, surface water, and springs/seeps along the northern drainage within the SSFL. The location of the northern drainage and its relationship to the SSFL RFI sites are shown on Figure 2. The objective of these tasks was to characterize the potential impacts of perchlorate, if any, along the northern drainage potentially associated with historical operations at the SSFL. Of the RFI sites located along or upgradient of the Northern Drainage, only the Building 359 Area has been documented to have used and stored perchlorate (Figure 2). Although the Building 359 RFI site does not lie within the catchment area of the Northern Drainage (Figure 3), an underground storm drain may have historically conveyed stormwater runoff from the eastern portion of the Building 359 RFI site to the Northern Drainage. This storm drain, now sealed, extended north from the Building 359 RFI site and discharged within the Area I Landfill RFI site. Surface water from the Area I Landfill RFI site flows into a tributary leading to the Northern Drainage (Figure 2). Based on numerous detections of perchlorate at the Building 359 RFI site, this storm water runoff may have contained perchlorate.

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The purpose of sampling described in this technical memorandum was to test sediments, surface water, or springs/seeps present within the northern drainage to evaluate potential offsite migration of perchlorate from the SSFL. The objective for collection and analysis of the drainage sediment and surface water samples was to evaluate the potential transport of perchlorate by surface water from the SSFL into the Northern Drainage. The objective for collecting and analyzing spring/seep samples was to evaluate the potential groundwater transport pathway from the Building 359 RFI site across geologic features and to confirm that perchlorate releases to groundwater remain local to their respective release location(s).

Based on the data presented in this document, perchlorate has not been detected in the media sampled within the Northern Drainage, nor in the tributaries leading to it except perhaps in one sample at the base of the Area I Landfill. As described in Section 4, perchlorate was not detected in two confirmed in two additional samples collected at this location. Thus, data collected to date continue to demonstrate that perchlorate detected at the SSFL has remained within close proximity to where perchlorate was primarily used, the Building 359 and Happy Valley RFI sites.

The sampling rationale and procedures used to collect drainage sediment, surface water and spring/seep samples along the northern drainage are described in Section 2.0. Section 3.0 provides information regarding sample analytical procedures and data review findings. Sampling results are described in Section 4.0, and conclusions are provided in Section 5.0. Sediment, surface water, and spring/seep sampling logs are provided in Appendix A. Data validation findings, reports, and analytical data are provided in Appendix B.

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2.0 SAMPLING RATIONALE AND PROCEDURES

Drainage sediment, surface water, springs/seeps, and selected bedrock/mineral deposits adjacent to springs/seeps were sampled in the Northern Drainage between July 8 and 24, 2003. Because of elevated detection limits, or to clarify indeterminate laboratory results, additional sediment samples were collected on August 27 and 28, and October 21, 2003.

A summary for the samples collected and analyses performed during this program is provided in Table 1. Sampling locations are depicted on Plate 1. The following sections describe the sampling rationale and procedures used. Laboratory procedures and analytical methods are described in Section 3.0 and Appendix B of this document.

A total of 79 locations were tested and 171 samples were collected and analyzed for perchlorate during this program (Tables 1 through 6; Plate 1). As described below, some locations/depths were re-sampled during this program, and some samples were analyzed multiple times to achieve lower detection limits or to clarify uncertain results. Only final sample results for each unique location and depth are included in the sample count above. In total, including duplicates and confirmation samples, 140 sediment leachate, 14 surface water, 15 spring/seep, and 2 rock chip samples were collected for this sampling program.

2.1 DRAINAGE SEDIMENT SAMPLING RATIONALE

Samples were collected from surficial and deeper sediments within the active channel of the Northern Drainage to evaluate the potential for surface water transport of perchlorate from the SSFL.

In general, the lateral spacing of sediment samples within the drainage increased with distance from the RFI sites, with a maximum lateral distance of 1000 feet as requested by DTSC. At or near RFI sites, the lateral spacing of these samples generally ranged from about 50 to 125 feet. Sediment sample locations near the Area I and Area II landfills were presented in the Area I and Area II Landfills Investigation Work Plan submitted to DTSC in June 2003 (MWH 2003c). A

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lateral spacing ranging from about 250 feet to 500 feet was used at those sampling locations away from RFI sites but within or immediately adjacent to the SSFL. North of the SSFL (offsite), the lateral spacing of sediment samples increased and ranged from about 500 to 1000 feet (MWH 2003d and 2003f).

Samples were collected at various depths across the width of the drainage as outlined below and illustrated on Plate 2 of this report. Table 2 summarizes the types and numbers of sediment samples collected during this program. In general, low spots at each sample location within the drainage area were targeted since these represent where the last surface water occurred. Samples were collected at depths between the surface and ½-inch below the surface (designated as sample S01) and at 6 inches above the bedrock (designated as sample S03). At approximately 10 percent of the sample locations, an additional sediment sample was collected between ½ inch and 4 inches below the surface (designated as sample S02). Additional samples of this type were collected in areas with thin sediment deposits that precluded collecting S03 samples (MWH 2003d and 2003f).

Sample locations were added along the drainage if salt deposits were noted. Similarly, if salt deposits were observed in the bank(s) of the drainage area, additional samples were collected (designated as sample S04). These samples were in addition to the sample intervals discussed in the previous paragraphs and targeted the salt-bearing interval only (MWH 2003d and 2003f).

At the two locations within the drainage where thicker sediment deposits were present, over-bank samples (designated as sample S05) and deeper samples were collected at approximately 6-inch depth intervals to just above bedrock (designated as samples S06, S07, etc.). Leachates were prepared (see below) on every other sample collected in these deeper borings; the remaining samples were retained onsite under standard chain-of-custody protocols pending the results of the leachates. Thick sediment accumulations were found in two locations: approximately 300 feet downslope of the Area I Landfill (NDLS03) and within a portion of the Brandeis-Bardin property north of the SSFL (NDLS55, NDLS56 and NDLS57) (Plate 1).

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If water was encountered in the bottom of an auger boring, water samples were collected using a disposable bailer or syringe device. This was the case for three borings in the lower reach drainage described above with the thicker soil accumulations (NDLS55, NDLS56, and NDLS57). In each of these borings, leachates were only obtained from unsaturated sediment above the water. Water samples were collected from the two borings that maintained their integrity (i.e., did not cave in). These borings and the associated surface water samples collected were NDLS55 and NDSW10, and NDLS57 and NDSW11. Water was encountered in these borings at 2.3 feet bgs and 3.5 feet bgs (Appendix A).

2.2 DRAINAGE SEDIMENT LEACHATE SAMPLING PROCEDURES

As described in the Perchlorate Characterization Work Plan, after the DTSC site review of the Happy Valley area, the RFI soil sampling approach for perchlorate was revised under DTSC direction in October 2000 to include collection of soil leachate samples to screen for potential perchlorate impacts in soil (MWH 2003d and 2003f). This approach was adopted because perchlorate compounds are highly soluble, and readily leach into water from soil. This 'original' leachate collection method, used until July 2003, allowed testing of a larger amount of soil for perchlorate than the small aliquot removed from a typical sampling container by the laboratory for analysis. The method is summarized as follows (MWH 2003a):

- Multiple sampling sleeves were collected from a single vertical hand-auger borehole, multiple hand-auger boreholes within a small area (generally 5 feet by 5 feet), or a trench wall or floor. The number of sampling sleeves would vary depending on the area tested, but generally included 3 to 6 sleeves. In some instances, soils were collected directly from the hand auger or in locations where soil cover was thin, using a trowel.

- Sleeves were partially emptied into a clean 5-gallon bucket, and sufficient de-ionized water added to saturate the soil, plus approximately 1 to 2 inches of free water covering the soil. The soil-water mixture was then stirred, allowed to settle, and the water decanted into a plastic bottle obtained from the laboratory. The soil wetting process was repeated until the plastic sampling bottle was full (usually two to four times).

- The leachate water sample and the partially emptied sleeves were labeled, sealed, and sent to the analytical laboratory under chain-of-custody procedures. Leachate water samples were filtered and analyzed at the laboratory for perchlorate. Associated soil samples were typically analyzed if perchlorate was detected in the leachate sample.

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Recently, an enhanced leachate procedure was developed based on recent information regarding similar perchlorate sampling methods at other perchlorate-impacted sites in California. This information indicates that very near-surface sediments concentrate perchlorate in areas with continuing sources. The modified sampling procedure was implemented for the Northern Drainage characterization since it allows for better quantification of perchlorate detected in the soils (i.e., a one-to-one water/soil ratio is used), and still targets both surficial and deeper sediments. The very surficial nature of the samples (at ½ inch) collected using the revised methodology targets any salts, including perchlorate, that rise or 'wick' to the sediment surface by capillary action as water evaporates at the surface. Leachates collected by this method were prepared by mixing approximately 250 grams of each soil/sediment sample with 250 milliliters of deionized water in laboratory supplied, pre-cleaned containers. The soil-water mixtures were shaken for 2 minutes, allowed to settle for 15 minutes, and shaken again and allowed to settle overnight. The water in the mixture was decanted as the leachate sample and submitted to the laboratory for analysis under appropriate chain-of-custody procedures.

The enhanced leachate procedure was recently used to sample in previously identified areas with perchlorate impacts at the Happy Valley and Building 359 RFI sites in preparation for the Happy Valley Interim Measures. Side-by-side samples were collected to allow a comparison between the original and enhanced methodologies, which differ in that the enhanced procedure uses standardized sample and water amounts, whereas the original leachate method does not (except in the most general sense of using 4 to 6 sampling sleeves). At these side-by-side comparison locations, the enhanced leachate procedure detected higher concentrations of perchlorate in the uppermost ½ inch of sediment than the original method detected in sediments collected between 0 and 6 inches. As described above, it is believed this result occurred because of perchlorate wicking to the surface and precipitating as a salt. Results of side-by-side samples are provided in and discussed further in the Perchlorate Characterization Work Plan (MWH 2003d and 2003f).

Side-by-side leachate samples were also collected during the Northern Drainage program to provide comparability between the original and enhanced methods at sample locations. Leachates were produced using both original and enhanced procedures from sediment samples collected at regular intervals using the original methodology developed between MWH and

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DTSC. The 'original' method leachates (S99 sample identification; total of 10 samples) were created from sediment samples collected from the surface to 6 inches bgs at a maximum lateral distance of 1000 feet. In areas of thicker sediment deposits, leachates of vertical composites (S90 sample identification; total of 2 samples) were also prepared using the original methodology. The depth assigned to each 'S90' sample was the average (half) of the boring depth for that sample.

2.3 SURFACE WATER

Surface water samples were collected from the Northern Drainage to evaluate potential surface water transport of perchlorate from the Building 359 RFI site and the Area I and II landfills into the drainage (MWH 2003d and 2003f). Surface water pools identified during an inspection of the drainage were sampled in July 2003; their locations are shown on Plate 1. In saturated portions of the drainage, samples were spaced equidistant with respect to springs/seeps and/or locations where water was encountered in borings. These samples were collected by submerging laboratory obtained sample bottles directly in the surface water stream or pool.

2.4 SPRINGS AND SEEPS

Water samples from springs/seeps located along the Northern Drainage were collected and analyzed for perchlorate to evaluate the potential transport of perchlorate in groundwater. Spring/seep sampling locations targeted were new springs/seeps identified in the Northern Drainage or those previously sampled for perchlorate. Spring/seep sampling locations identified during an inspection of the drainage were sampled in July 2003 and are shown on Plate 1. Three springs/seeps are located in tributaries leading to the Northern Drainage (S9, S10, and S31). For ease of reference, these seeps/springs are referred to as being located in the Eastern Drainage. The catchment area for the Eastern Drainage is shown in Figure 3.

Springs/seeps with enough flow to form a pool were sampled by submerging the appropriate sample bottles directly in the pool. Those that did not have sufficient flow were sampled by one of the two following methods:

- An artificial dam was constructed out of silicone and polyvinyl chloride (PVC) tubing and placed at the base of the seep along the fracture to direct flow into the sample

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bottle(s), which were left to fill overnight. For laboratory quality control, rinse water samples were obtained by running deionized water over the hardened dam silicone material and analyzed for perchlorate. This sample method was only used at spring S30 (SSSW12).

- The spring/seep sample was collected using a pre-cleaned, disposable plastic syringe and transferred to the appropriate sample bottle(s). This sample method was used at all locations other than that described for spring S30.

Rock chip samples were collected at spring/seep locations where mineral precipitate deposits were noted adjacent to the spring to verify the presence or absence of perchlorate in spring/seep water (MWH 2003d and 2003f).

Mineral precipitate deposits were noted at two spring/seep locations (S30 and S33) during an inspection of the Northern Drainage. At seep location S30, a mineral precipitate (a white crust, possibly some form of carbonate) associated with the seep water was found along a fracture surface in sandstone. At this location, the mineral crust and adjacent, wet bedrock were collected. The rock chip sample was soft and easily crushed by the field team, so a leachate sample (NDRC01) was prepared using the methodology described above. At location S33, a travertine mineral deposit was found along a near-vertical wall of sandstone adjacent to the spring/seep. A portion of the travertine precipitate at this location was chipped away and submitted to the laboratory for further crushing so the resulting fine material could be analyzed for perchlorate (sample NDRC02).

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3.0 LABORATORY ANALYSIS

Laboratory analysis was conducted during this program as specified in the Perchlorate Characterization Work Plan (MWH, 2003d and 2003f). In general, the procedures and methods follow the quality assurance criteria specified in the RFI Quality Assurance Project Plan (Ogden 2000b and 2000c). Information for all samples collected during this program is provided in Table 1, including sample identifier, depth, location, analyses performed, laboratories used, and validation report number. Further detail regarding laboratory analytical procedures and data validation findings are provided in Appendix B.

3.1 PERCHLORATE ANALYSIS

All samples were analyzed for perchlorate using United States Environmental Protection Agency (EPA) Method 314.0. All perchlorate sample analysis was performed at Del Mar Analytical Laboratory (Del Mar), a California-certified laboratory located in Irvine, California. Surface water and spring/seep samples were analyzed at Ceimic Corporation laboratory, located in Narragansett, Rhode Island. Although Ceimic was not California-certified during this period (due to an administrative lapse), they were certified both nationally and through the state of Florida for perchlorate analysis using Method 314.0 (California recognizes Florida certification for perchlorate).

The typical soil matrix (or rock chip) sample reporting limit is 40 micrograms per kilogram (µg/kg), with a laboratory method detection limit of less than 20 µg/kg. Similar to the RFI, laboratories used for this program are required to report any perchlorate detected below the reporting limit but above the method detection limit as an estimated value. As described above, of the two rock chip samples collected as part of this program, only one (NDRC02) was crushed by the laboratory and analyzed following the methodology established for soil matrix samples. The second rock chip sample was very soft and crushed by field personnel and a rock leachate submitted to the laboratory (NDRC01).

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The typical sample reporting limit for water samples (spring/seep, and sediment leachate) is 4 micrograms per liter (µg/L), with a method detection limit of less than 1 µg/L. Again, laboratories used for this analysis are required to report any perchlorate detected below the reporting limit but above the method detection limit as an estimated value.

Naturally occurring matrix interference can cause some reporting limits for water or soil samples to be raised. Typical interference causing constituents include nitrate, sulfate, chloride, and several types of organic compounds. In some cases, samples can just be rerun with sufficient blank samples between the site samples to reduce instrument carryover caused by these interfering compounds. In other cases, additional steps were necessary to reduce matrix interference. Recent research by the EPA and commercial laboratories has identified procedures that can be performed utilizing a cartridge to remove the interfering constituent(s) without affecting perchlorate concentrations. These steps and the use of pre-treatment cartridges are acceptable within EPA Method 314.0. The laboratory must conduct and document proper quality control sample procedures to ensure that perchlorate was neither added nor removed by the additional procedures.

During the Northern Drainage sampling event, elevated detection limits due to organic interference were encountered in some surface water and spring/seep samples, as well as in leachate samples. Since Ceimic was familiar with the Method 314.0 requirements using treatment cartridges, these additional steps were performed on all samples analyzed by Ceimic. However, Del Mar did not have experience with using the cartridges for matrix interference encountered in the sediment leachate samples. Therefore, 21 samples were sent from Del Mar to APPL Laboratories, a California-certified laboratory located in Fresno. Because sample holding times had been exceeded in some of these shipped samples, 18 additional samples were also collected on August 27 and 28, 2003 at these locations and submitted directly to APPL (Table 1). Both the original sample and newly submitted sample were analyzed using the treatment cartridges to achieve the lowest possible detection limit.

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In the cases where a treatment cartridge was used, the laboratory would run the samples as submitted, and if interference caused an increased reporting limit, the sample would be passed through a cartridge to remove the interfering constituent, and the sample re-run. The laboratory implemented appropriate quality control procedures to verify no change in potential perchlorate concentrations.

In addition to these added laboratory measures to keep the detection limits as low as possible, the presence or absence of perchlorate at low concentrations was verified using laboratory prepared standard (where the sample is analyzed after spiking it with a known amount of perchlorate).

Finally, the presence/absence of perchlorate in some samples was indeterminate based on the chromatogram results, even when all of the above-mentioned laboratory procedures were implemented. Therefore, seven sediment leachate samples were analyzed using Method 8321 at Severn Trent Laboratory (STL), a California-certified laboratory located in Denver, Colorado. Method 8321 uses a liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) procedure that allows better resolution of the perchlorate ion. Although not accredited by EPA for perchlorate, the LC/MS/MS method can be used as a confirmation technique because it is generally accepted in the scientific community (Simmons 2003), and has strict quality assurance procedures. It should be noted that STL-Denver is a California-certified laboratory for Methods 314.0 and 8321 (Method 8321 is a EPA-approved method for other compounds).

All perchlorate sampling results were validated by a qualified chemist and, in cases of multiple results for a single sample, the most technically sound result was reported (Appendix B). The factors used to determine the most technically sound result included the lowest achievable detection limit, the use of pretreatment cartridges to remove matrix interference, the dilution factor used (if any), and the chemists' professional evaluation of the quality of the chromatography.

3.2 OTHER ANALYSES

Spring/seep samples were also analyzed for selected general minerals and isotopes to provide information as to the source of the water (i.e., groundwater or surface water). The general

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minerals analyses included selected anions (chloride, sulfate, carbonate, bicarbonate), and total dissolved solids (TDS) using EPA Methods 300 and 160.1, respectively. The isotopic analyses included stable hydrogen (deuterium) and oxygen isotopes, ^{2}H and ^{18}O, respectively.

Del Mar performed all of the anions and TDS analyses. Similar to perchlorate, these were validated by a qualified chemist (Appendix B). The University of Waterloo located in Waterloo, Ontario, Canada analyzed samples for hydrogen and oxygen isotopes.

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4.0 SAMPLING RESULTS

The following sections describe the sediment leachate, surface water, and spring/seep sampling results collected in the Northern Drainage during summer/fall 2003. Overall 172 samples were collected from 79 locations over a distance along the drainage of about 15,000 feet (3 miles).

4.1 SEDIMENT LEACHATE SAMPLING RESULTS

All sediment leachate sample results are provided in Table 3, and depicted on Plate 1. Additional descriptions of specific sample locations within the Northern Drainage are provided in Appendix A, and validation and laboratory reports provided in Appendix B. As described above, a total of 140 sediment leachate samples were collected from 64 locations and analyzed for perchlorate.

Perchlorate was not confirmed to be detected in any sediment leachate sample collected in the northern drainage, except perhaps in one sample collected near the base of the Area I Landfill (NDLS06S01, EPA_ID ML522) within the SSFL boundary. This sample had a reported estimated detect of 3.6 µg/L. This result could not be confirmed using Method 8321 using LC/MS/MS analysis because sample volume was exhausted. Therefore, two additional samples were collected and analyzed at this location and depth. On August 27, 2003 a sample was collected and analyzed at APPL using Method 314.0 (EPA_ID MT147). On October 20, 2003, another sample was collected and analyzed at STL using Method 8321 (EPA_ID MG633). Perchlorate was not detected in either sample collected in August or October at this location. Therefore, the presence of perchlorate in this portion of the drainage below the landfill is not confirmed and considered unlikely given the low concentration reported (below the reporting limit).

Perchlorate was not detected in any other sediment leachate samples collected within the Northern Drainage. As described above, additional laboratory procedures were utilized to obtain the lowest detection limits possible for Method 314.0. In general, the detection limits for the sediment leachate samples were less than 4 µg/L although a few ranged up to 30 µg/L (Table 3). Seven samples (including the one described above) required re-analysis using Method 8321 to

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confirm the presence/absence of perchlorate due to detection limits that could not be lowered with pretreatment or due to uncertain results (Table 1). In all cases, the reanalysis of the samples by Method 8321 confirmed that samples did not contain detectable perchlorate.

Finally, it should be noted the 'enhanced' and 'original' leachate sampling results were comparable at each of location since all results were non-detect.

4.2 PERCHLORATE IN SURFACE WATER

Surface water sample results are provided in Table 4, and depicted on Plate 1. Perchlorate was not detected in any of the 14 samples collected from 9 locations. As described above, due to matrix interference use of treatment cartridges were necessary to achieve the lowest possible reporting limits (less than 4 µg/L).

4.3 PERCHLORATE IN SPRINGS/SEEPS AND ASSOCIATED ROCK CHIPS

Spring/seep sampling results are provided in Table 5, and depicted on Plate 1. Perchlorate was not detected in any of the 15 samples collected from 8 locations. Again, due to matrix interference use of treatment cartridges were necessary to achieve as low as possible reporting limits (less than 4 µg/L).

As described in Section 2, rock chip samples from surrounding bedrock or mineral deposits were collected adjacent to spring/seeps S30 and S33. These rock chip results are provided in Table 6 and depicted on Plate 1. Neither sample contained detectable perchlorate at reporting limits of 4 µg/L (leachate rock chip sample) or 40 µg/kg (rock matrix sample).

4.4 STABLE HYDROGEN AND OXYGEN ISOTOPES IN SURFACE WATER POOLS AND SPRINGS/SEEPS

Surface water and spring/seep sample results for stable isotopes (δ^2H and $\delta^{18}O$) are provided in Table 7, and depicted on Figure 4. Also shown on Figure 4, are the stable isotopes results from other surface water and groundwater samples historically collected at the SSFL (see Stable Isotope Hydrogeologic Evaluation at the Santa Susana Field Laboratory [Smith and Menchaca

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1995, and MWH 2003b]). These data are plotted relative to the meteoric water line[1] (MWL). As can be seen on Figure 4, four of the surface water samples collected in July of 2003 (NDSW04, NDSW05, NDSW08 and NDSW09) are representative of waters showing various losses to evaporation. Two of the samples (NDSW03 and NDSW06) show the same isotopic signature as measurements made from groundwater samples collected from wells at or near the SSFL.

The stable isotope results from all but one of the eight springs/seeps sampled in July 2003 fall in the same grouping as historical results of samples from wells that monitor Chatsworth formation groundwater. These data confirm that spring/seep waters are derived from groundwater that emerges at these locations. The sample results from SSSW14 (spring/seep S10) fall below the MWL and along the evaporation line as can be seen on Figure 4; hence they are indicative of waters that have been evaporated. These data indicate that the sample collected from spring/seep S10 was either surface water that had been present long enough to have evaporated or groundwater that emerged previously and had evaporated.

4.5 ANIONS AND TDS IN SURFACE WATER POOLS AND SPRINGS/SEEPS

Surface water and spring/seep sample results for general minerals and TDS are provided in Table 8. The analytical results for the anions at each surface water pool and spring/seep are graphically depicted as stiff diagrams on Plate 2. Plate 2 also depicts stiff diagrams of anions from historical groundwater and spring/seep samples collected within or near the Northern Drainage. (Anion-only stiff diagrams are shown because cations [sodium, calcium, magnesium, and potassium] were not analyzed due to limited water volume available at most sampling locations.)

In the surface water samples, chloride concentrations ranged from 6.4 milligrams per liter (mg/L) at NDSW09 to 120 mg/L at NDSW05 and sulfate concentrations ranged from 6.7 mg/L at NDSW09 to 290 mg/L at NDSW05. Carbonate alkalinity was measured in only one of the six samples (NDSW03) at a concentration of 4 mg/L; the other five samples did not contain

[1] The global meteoric water line (MWL) defines the relationship between ^{18}O and ^{2}H in worldwide fresh surface waters as published by Harmon Craig (1961). The MWL is global only in application and is actually an average of many local or regional meteoric water lines that differ from the global line due to local changes in the climate and geography (Clark and Fritz 1999).

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carbonate above the laboratory reporting limit of 2 mg/L. Bicarbonate alkalinity measured from 46 mg/L at NDSW09 to 380 mg/L at NDSW06. TDS ranged from approximately 60 mg/L at NDSW09 to 900 mg/L at NDSW05. With the exception the NDSW05 sample, surface water primarily exhibits a bicarbonate-type anion signature. Additionally, the concentrations of all anions in two of the surface water samples (NDSW08 and NDSW09) were relatively low as can be seen on Plate 2 and Table 8. These samples (NDSW08 and NDSW09) were located in the southwest-flowing tributary of the Northern Drainage near the Instrument Equipment Laboratory (IEL) RFI site. The four remaining samples were located north of the SSFL along the Northern Drainage.

In spring/seep samples, chloride concentrations ranged from a low of 19 mg/L at SSSW14 (spring/seep S10), which is located along the Eastern Drainage, to a high of 46 mg/L at both SSSW10 (spring/seep S13) and SSSW15 (spring/seep S31). Sulfate concentrations ranged from a low of 39 mg/L at SSSW14 (spring/seep S10) to a high of 240 mg/L at both SSSW10 (spring/seep S13) and SSSW17 (spring/seep S33). Carbonate alkalinity was measured in only one of the eight samples (SSSW12, spring/seep S30) at a concentration of 4 mg/L; the other seven samples did not contain carbonate present above the laboratory reporting limit of 2 mg/L. Bicarbonate alkalinity measured from a low of 130 mg/L at SSSW17 (spring/seep S33) to a high of 1400 mg/L at SSSW10 (spring/seep S13). TDS ranged from approximately 550 mg/L at SSSW17 (spring/seep S33) to approximately 890 mg/L at SSSW10 (spring/seep S13). With the exception of the sample from SSSW17 (spring/seep S33), the spring/seep waters primarily exhibit a bicarbonate-type anion signature.

4.6 ANALYSIS OF WATER SOURCE FOR SURFACE WATER POOLS AND SPRINGS/SEEPS

The stable hydrogen and oxygen isotope results coupled with the anion results allow for a determination as to the source of water comprising surface water pool and spring/seep samples. Isotopic analysis was conducted on 6 of the 9 samples collected due to a limited water volume available for three of the samples (Table 8). Two of the six samples collected from surface water pools (NDSW03 and NDSW06) had stable isotope ratios that are indicative of groundwater (Figure 4). The concentrations of chloride in both of these samples are also in the same range as chloride concentrations in other groundwater wells at and near the SSFL. Therefore, it is

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concluded that the samples collected from these two surface water pools are sourced from groundwater.

The four remaining surface water samples had stable isotope ratios that fall on the evaporitic line (i.e., these samples are depleted in ^{16}O relative to the MWL). Evaluation of the anion results, and in particular the chloride values, indicates that samples collected at NDSW04 and NDSW05 are representative of groundwater because the chloride concentrations are in the same range as other groundwater wells at and near the SSFL. The chloride concentrations at NDSW04 and NDSW05 were 40 mg/L and 120 mg/L, respectively, while the site-wide concentration of chloride in SSFL Chatsworth formation monitoring wells is 54 mg/L. Alternately, the concentration of chloride in samples from NDSW08 and NDSW09 were only 7.3 mg/L and 6.4 mg/L, respectively. Concentrations of other anions were also significantly lower than the other surface water and spring/seep samples as can be seen in the stiff diagrams on Plate 2. Therefore, it is concluded that the NDSW08 and NDSW09 samples are from surface water runoff.

Inspection of the stable isotope ratios depicted on Figure 4 shows that seven of the eight spring/seep samples had ratios similar to that of historical samples from other groundwater monitoring wells and springs/seeps at and near the SSFL. These results, along with the concentrations of chloride, confirm that samples collected from these locations are sourced from groundwater. Alternately, the stable isotope ratio at location SSSW14 (spring/seep S10) falls on the evaporitic line. Analysis of the anion concentrations from this sample shows that the concentrations of both chloride (19 mg/L) and sulfate (39 mg/L) are lower than most of the other springs/seeps and surface water pools that were determined to be sourced from groundwater. Additionally, the stiff diagram for this sample is similar in shape to the surface water samples collected at NDSW08 and NDSW09 as can be seen on Plate 2. These data indicate that the sample collected from SSSW14 is likely a mixture of groundwater and surface water due to its moderate chloride concentration, lower sulfate concentration, and an evaporitic stable isotope ratio.

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5.0 SUMMARY AND CONCLUSIONS

Boeing sampled surficial media within the Northern Drainage based on conflicting and questionable perchlorate groundwater sample results from offsite well OS-9. Sediment and surface water sampling was performed to test perchlorate migration via the surface water pathway, and spring/seep sampling was performed to test perchlorate migration via the groundwater pathway. Samples were collected at regular intervals both on- and offsite of the SSFL within the drainage, with at a higher frequency near RFI sites. All samples were analyzed for perchlorate. Surface water and spring/seep samples were also analyzed for stable hydrogen and oxygen isotopes, anions, and total dissolved solids to assess general water quality conditions and to evaluate the source of water at these locations. All laboratory data were carefully reviewed and validated.

The results of the Northern Drainage sampling program are:

- A total of 171 sediment leachate, surface water, spring/seep and rock chip samples were collected from 79 locations over a distance of about 3 miles
- Perchlorate was not detected in any of the 71 offsite samples
- All 140 sediment leachate samples were non detect, with one possible exception in the upper portion of the drainage near the base of the Area I Landfill
  - This sample had a reported concentration of 3.6 µg/L (estimated below the laboratory reporting limit)
  - Resampling at this location did not detect perchlorate
  - 137 sediment leachate samples were located downstream of this location; perchlorate was not detected in any downstream sample
- All 14 surface water samples were non detect for perchlorate
  - The source of water at 4 of 6 surface water locations was groundwater, the other two locations were from surface water runoff
- All 15 spring/seep and 2 associated rock chip samples were non detect for perchlorate
  - The source of water at 7 of 8 spring/seep locations was groundwater; one was a mixture of groundwater and surface water

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Based on these results, the following conclusions are made:

1) Sediment and surface water data collected during this program indicate that perchlorate has not been transported offsite via the surface water pathway within the Northern Drainage.

2) The spring/seep data collected during this program, coupled with other groundwater data presented in the Perchlorate Characterization Work Plan (MWH 2003f), indicate that perchlorate has not been transported offsite via the groundwater pathway to the Northern Drainage area. Additional testing of the groundwater pathway is in progress or planned to further evaluate this conclusion.

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Table 1A (Page 1 of 5)

Drainage Sediment Leachate
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Depth (feet bgs)	Perchlorate 314.0	Perchlorate 8321	Laboratory
NDLS01S01	ML514	7/8/2003	0.04	X		DELMAR
NDLS02S01	ML515	7/8/2003	0.04	X		DELMAR
NDLS03D01	ML517	7/8/2003	0.04	X		DELMAR
NDLS03S01	ML516	7/8/2003	0.04	X		DELMAR
NDLS03S02	ML518	7/8/2003	0.33	X		DELMAR
NDLS03S03	ML519	7/8/2003	4.0	X		DELMAR
NDLS03S06	ML535	7/10/2003	1.75	X		DELMAR
NDLS03S09	ML536	7/10/2003	2.5	X		DELMAR
NDLS03S11	ML537	7/10/2003	3.5	X		DELMAR
NDLS03S90	MJ519	7/24/2003	2.25	X		DELMAR
NDLS03S99	MJ516	7/24/2003	0.5	X		DELMAR
NDLS04S01	ML520	7/8/2003	0.04	X		DELMAR
NDLS04S04	ML524	7/8/2003	0.04	X		DELMAR
NDLS04S04	ML524AP	7/8/2003	0.04	X		APPL
NDLS04S04	MT146	8/27/2003	0.04	X		APPL
NDLS05S01	ML521	7/8/2003	0.04	X		DELMAR
NDLS06S01	MG633	10/20/2003	0.04	X	X	DELMAR-STL
NDLS06S01	ML522	7/8/2003	0.04	X		DELMAR
NDLS06S01	ML522AP	7/8/2003	0.04	X		APPL
NDLS06S01	MT147	8/27/2003	0.04	X		APPL
NDLS07S01	ML523	7/8/2003	0.04	X		DELMAR
NDLS08S01	ML527	7/9/2003	0.04	X		DELMAR
NDLS09S01	ML528	7/9/2003	0.04	X		DELMAR
NDLS10S01	ML529	7/9/2003	0.04	X		DELMAR
NDLS10S03	ML530	7/9/2003	1.2	X		DELMAR
NDLS10S99	MJ529	7/25/2003	0.5	X		DELMAR
NDLS11S01	ML531	7/9/2003	0.04	X		DELMAR
NDLS11S03	ML532	7/9/2003	0.9	X		DELMAR
NDLS12S01	ML533	7/9/2003	0.04	X		DELMAR
NDLS13S01	ML534	7/9/2003	0.04	X		DELMAR
NDLS14S01	MD540	7/10/2003	0.04	X		DELMAR
NDLS14S02	ML541	7/10/2003	0.33	X		DELMAR
NDLS14S03	ML542	7/10/2003	3.0	X		DELMAR
NDLS14S99	MJ540	7/10/2003	0.5	X		DELMAR
NDLS15S01	ML543	7/10/2003	0.04	X		DELMAR
NDLS16S01	ML544	7/10/2003	0.04	X		DELMAR
NDLS16S01	ML544AP	7/10/2003	0.04	X		APPL
NDLS16S01	MT148	8/27/2003	0.04	X		APPL
NDLS17S01	ML545	7/10/2003	0.04	X		DELMAR
NDLS17S02	ML546	7/10/2003	0.33	X		DELMAR
NDLS18S01	ML552	7/10/2003	0.04	X		DELMAR

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Drainage Sediment Leachate
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Depth (feet bgs)	Perchlorate 314.0	Perchlorate 8321	Laboratory
NDLS18S02	ML553	7/10/2003	0.33	X		DELMAR
NDLS18S03	ML554	7/10/2003	0.8	X		DELMAR
NDLS19S01	ML547	7/10/2003	0.04	X		DELMAR
NDLS19S02	ML548	7/10/2003	0.33	X		DELMAR
NDLS20S01	ML549	7/10/2003	0.04	X		DELMAR
NDLS22S01	ML555	7/11/2003	0.04	X		DELMAR
NDLS23S01	ML556	7/11/2003	0.04	X		DELMAR
NDLS24S01	ML557	7/11/2003	0.04	X		DELMAR
NDLS24S99	MJ557	7/24/2003	0.5	X		DELMAR
NDLS25S01	ML558	7/11/2003	0.04	X		DELMAR
NDLS26S01	ML559	7/14/2003	0.04	X		DELMAR
NDLS26S01	ML559AP	7/14/2003	0.04	X		APPL
NDLS26S01	MT150	8/27/2003	0.04	X	X	APPL-STL
NDLS27S01	ML560	7/14/2003	0.04	X		DELMAR
NDLS27S01	ML560AP	7/14/2003	0.04	X		APPL
NDLS27S01	MT151	8/27/2003	0.04	X		APPL
NDLS28S01	ML561	7/14/2003	0.04	X		DELMAR
NDLS28S01	ML561AP	7/14/2003	0.04	X		APPL
NDLS28S01	MT152	8/27/2003	0.04	X	X	APPL-STL
NDLS28S02	ML562	7/14/2003	0.33	X		DELMAR
NDLS29S01	ML563	7/14/2003	0.04	X		DELMAR
NDLS29S01	ML563AP	7/14/2003	0.04	X		APPL
NDLS29S01	MT153	8/27/2003	0.04	X		APPL
NDLS29S02	ML564	7/14/2003	0.033	X		DELMAR
NDLS30S01	ML565	7/14/2003	0.04	X		DELMAR
NDLS31S01	ML566	7/14/2003	0.04	X		DELMAR
NDLS32S01	ML567	7/14/2003	0.04	X		DELMAR
NDLS32D03	MJ568	7/24/2003	2.2	X		DELMAR
NDLS32S03	ML628	7/24/2003	2.2	X		DELMAR
NDLS32S99	MJ567	7/24/2003	0.5	X		DELMAR
NDLS33S01	ML568	7/14/2003	0.04	X		DELMAR
NDLS34S01	ML569	7/14/2003	0.04	X		DELMAR
NDLS35S01	ML570	7/14/2003	0.04	X		DELMAR
NDLS35S01	ML570AP	7/14/2003	0.04	X		APPL
NDLS35S01	MT154	8/27/2003	0.04	X		APPL
NDLS36S05	MD571	7/14/2003	0.04	X		DELMAR
NDLS36S99	MJ571	7/24/2003	0.5	X		DELMAR
NDLS37S01	ML572	7/14/2003	0.04	X		DELMAR
NDLS38S01	ML573	7/14/2003	0.04	X		DELMAR
NDLS39S01	ML576	7/15/2003	0.04	X		DELMAR
NDLS40S01	ML577	7/15/2003	0.04	X		DELMAR

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Drainage Sediment Leachate
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Depth (feet bgs)	Perchlorate 314.0	Perchlorate 8321	Laboratory
NDLS40S01	ML577AP	7/15/2003	0.04	X		APPL
NDLS40S01	MT155	8/27/2003	0.04	X		APPL
NDLS41S01	ML578	7/15/2003	0.04	X		DELMAR
NDLS41S01	ML578AP	7/15/2003	0.04	X		APPL
NDLS41S01	MT156	8/27/2003	0.04	X		APPL
NDLS41S02	ML579	7/15/2003	0.33	X		DELMAR
NDLS42S01	ML580	7/15/2003	0.04	X		DELMAR
NDLS43S01	ML581	7/15/2003	0.04	X		DELMAR
NDLS44S01	ML582	7/15/2003	0.04	X		DELMAR
NDLS44S04	ML583	7/15/2003	0.04	X		DELMAR
NDLS44S04	ML583AP	7/15/2003	0.04	X		APPL
NDLS44S04	MT157	8/27/2003	0.04	X		APPL
NDLS45S01	ML584	7/15/2003	0.04	X		DELMAR
NDLS46S01	ML585	7/15/2003	0.04	X		DELMAR
NDLS46S99	MJ585	7/24/2003	0.5	X		DELMAR
NDLS47S01	ML586	7/15/2003	0.04	X		DELMAR
NDLS48S01	ML587	7/15/2003	0.04	X		DELMAR
NDLS48S99	MJ587	7/25/2003	0.5	X		DELMAR
NDLS49S01	ML588	7/15/2003	0.04	X		DELMAR
NDLS50S01	ML589	7/16/2003	0.04	X		DELMAR
NDLS51S01	ML590	7/16/2003	0.04	X		DELMAR
NDLS51S01	ML590AP	7/16/2003	0.04	X		APPL
NDLS51S01	MT159	8/28/2003	0.04	X	X	APPL-STL
NDLS51S02	ML591	7/16/2003	0.33	X		DELMAR
NDLS51S99	MJ590	7/25/2003	0.5	X		DELMAR
NDLS51S99	MJ590AP	7/25/2003	0.5	X		APPL
NDLS51S99	MT160	8/28/2003	0.5	X		APPL
NDLS52S01	ML592	7/16/2003	0.04	X		DELMAR
NDLS52S01	ML592AP	7/16/2003	0.04	X		APPL
NDLS52S01	MT161	8/28/2003	0.04	X		APPL
NDLS52S99	MJ592	7/25/2003	0.5	X		DELMAR
NDLS53S01	ML593	7/16/2003	0.04	X		DELMAR
NDLS53S04	ML594	7/16/2003	0.04	X		DELMAR
NDLS53S04	ML594AP	7/16/2003	0.04	X		APPL
NDLS53S04	MT162	8/28/2003	0.04	X	X	APPL-STL
NDLS53S99	MJ593	7/25/2003	0.5	X		DELMAR
NDLS54S01	ML595	7/16/2003	0.04	X		DELMAR
NDLS54S01	ML595AP	7/16/2003	0.04	X		APPL
NDLS54S01	MT163	8/28/2003	0.04	X	X	APPL-STL
NDLS54S04	ML596	7/16/2003	0.04	X		DELMAR
NDLS54S04	ML596AP	7/16/2003	0.04	X		APPL

Drainage Sediment Leachate
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Depth (feet bgs)	Perchlorate 314.0	Perchlorate 8321	Laboratory
NDLS54S04	ML596RR	7/16/2003	0.04	X		DELMAR
NDLS54S04	MT164	8/28/2003	0.04	X	X	APPL-STL
NDLS55S01	ML597	7/16/2003	0.04	X		DELMAR
NDLS55S04	ML598	7/16/2003	0.04	X		DELMAR
NDLS55S04	ML598AP	7/16/2003	0.04	X		APPL
NDLS55S04	MT165	8/28/2003	0.04	X		APPL
NDLS55S06	ML610	7/17/2003	1.0	X		DELMAR
NDLS55S08	ML611	7/17/2003	3.0	X		DELMAR
NDLS55S90	MJ598	7/25/2003	2.2	X		DELMAR
NDLS55S99	MJ297	7/16/2003	0.5	X		DELMAR
NDLS56S01	ML599	7/16/2003	0.04	X		DELMAR
NDLS56S03	ML612	7/17/2003	4.5	X		DELMAR
NDLS56S04	ML600	7/16/2003	0.04	X		DELMAR
NDLS56S06	ML613	7/17/2003	0.8	X		DELMAR
NDLS56S99	MJ298	7/16/2003	0.5	X		DELMAR
NDLS57S01	ML601	7/16/2003	0.04	X		DELMAR
NDLS57S01	ML601AP	7/16/2003	0.04	X		APPL
NDLS57S01	MT166	8/28/2003	0.04	X		APPL
NDLS57S03	ML614	7/17/2003	4.6	X		DELMAR
NDLS57S04	ML602	7/16/2003	0.04	X		DELMAR
NDLS57S06	ML615	7/17/2003	1.3	X		DELMAR
NDLS57S08	ML616	7/17/2003	3.2	X		DELMAR
NDLS57S08	ML616AP	7/17/2003	3.2	X		APPL
NDLS57S08	MT167	8/29/2003	3.2	X		APPL
NDLS57S99	MJ299	7/16/2003	0.5	X		DELMAR
NDLS58S04	ML603	7/16/2003	0.04	X		DELMAR
NDLS59S01	ML550	7/10/2003	0.04	X		DELMAR
NDLS59S01	ML550AP	7/10/2003	0.04	X		APPL
NDLS59S01	MT158	8/27/2003	0.04	X		APPL
NDLS60S03	ML617	7/17/2003	3.5	X		DELMAR
NDLS60S07	ML618	7/17/2003	2	X		DELMAR
NDLS61S01	ML619	7/17/2003	0.04	X		DELMAR
NDLS62S01	ML620	7/17/2003	0.04	X		DELMAR
NDLS63S01	ML621	7/17/2003	0.04	X		DELMAR
NDLS64S01	ML623	7/24/2003	0.04	X		DELMAR
NDLS64S02	ML624	7/24/2003	0.5	X		DELMAR
NDLS64S03	ML625	7/24/2003	1.5	X		DELMAR
NDLS65S02	ML626	7/24/2003	0.5	X		DELMAR
NDLS65S03	ML627	7/24/2003	1.1	X		DELMAR

Notes:

ND Sampling TM

Drainage Sediment Leachate
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Depth (feet bgs)	Perchlorate 314.0	Perchlorate 8321	Laboratory

Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)

This table lists all samples collected and all analyses requested during the sampling program.

Sample Identification = RFI site and sample identifier code

Lab Identification = Laboratory reporting code

Lab Identification Designators:

"MD" Prefix = Primary samples shipped directly to Del Mar Analytical.

"MJ" Prefix = Primary sample generated using "original" leaching method.

"ML" Prefix = Primary samples shipped to Del Mar Analytical by Ceimic.
Transferred by order of MWH following notification of lapse in Ceimic's California state certification.

"MW" Prefix = Primary sample aliquot analyzed for stable Hydrogen and Oxygen isotopes at University of Waterloo.

"AP" Suffix = Primary samples subcontracted to APPL by Del Mar Analytical.

"C" Suffix = Confirmation split sample analyzed at Ceimic .

bgs = below ground surface

Perchlorate Analytical Methods:

USEPA Method 314.0 by Ion Chromatography (IC)

USEPA Method 8321 by Liquid Chromatography Thermospray Tandem Mass Spectrometry (LC/MS/MS)

APPL = Agriculture & Priority Pollutants Laboratories, Fresno, CA
CEIMIC = Ceimic Corporation Laboratory, Narragansett, RI
DELMAR = Del Mar Analytical Laboratory, Irvine, CA
STL = Severn Trent Laboratories, Denver, CO

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Table 1B (Page 1 of 1)

Surface Water
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Date Collected	Perchlorate 314.0	Anions 300M	TDS 160.1	Deuterium	Oxygen-18	Laboratory
NDSW03S01	MD503	7/1/2003	X					DELMAR
NDSW03S01	ML503	7/1/2003		X	X			DELMAR
NDSW03S01	ML503C	7/1/2003	X					CEIMIC
NDSW03S01	MW503	7/1/2003				X	X	WATERLOO
NDSW04S01	MD504	7/1/2003	X					DELMAR
NDSW04S01	ML504	7/1/2003		X	X			DELMAR
NDSW04S01	ML504C	7/1/2003	X					CEIMIC
NDSW04S01	MW504	7/1/2003				X	X	WATERLOO
NDSW05S01	MD505	7/1/2003	X					DELMAR
NDSW05S01	ML505	7/1/2003		X	X			DELMAR
NDSW05S01	ML505C	7/1/2003	X					CEIMIC
NDSW05S01	MW505	7/1/2003				X	X	WATERLOO
NDSW06S01	MD506	7/1/2003	X					DELMAR
NDSW06S01	ML506	7/1/2003		X	X			DELMAR
NDSW06S01	ML506C	7/1/2003	X					CEIMIC
NDSW06S01	MW506	7/1/2003				X	X	WATERLOO
NDSW07S01	ML507	7/1/2003	X					DELMAR
NDSW07S01	ML507C	7/1/2003	X					CEIMIC
NDSW08S01	MD538	7/10/2003	X					DELMAR
NDSW08D01	ML539	7/10/2003	X					DELMAR
NDSW08S01	ML551	7/11/2003		X				DELMAR
NDSW08D01	ML575	7/15/2003		X				DELMAR
NDSW08S01	MW538	7/10/2003				X	X	WATERLOO
NDSW09S01	MD574	7/15/2003	X					DELMAR
NDSW09S01	ML574	7/15/2003		X				DELMAR
NDSW09S01	MW574	7/15/2003				X	X	WATERLOO
NDSW10S01	ML608	7/17/2003	X					DELMAR
NDSW11S01	ML609	7/17/2003	X					DELMAR

Notes:
Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)
This table lists all samples collected and all analyses requested during the sampling program.
Sample Identification = RFI site and sample identifier code
Lab Identification = Laboratory reporting code
Lab Identification Designators:

"MD" Prefix = Primary samples shipped directly to Del Mar Analytical
"ML" Prefix = Primary samples shipped to Del Mar Analytical by Ceimic.
Transferred by order of MWH following notification of lapse in Ceimic's California state certification.
"MW" Prefix = Primary sample aliquot analyzed for stable Hydrogen and Oxygen isotopes at University of Waterloo
"C" Suffix = Confirmation split sample analyzed at Ceimic

Anions = Alkalinity, Chloride, Sulfate
TDS = Total Dissolved Solids

Perchlorate Analytical Method:
USEPA Method 314.0 by Ion Chromatography (IC)

CEIMIC = Ceimic Corporation Laboratory, Narragansett, RI
DELMAR – Del Mar Analytical Laboratory, Irvine, CA
WATERLOO = University of Waterloo, Waterloo, Ontario, Canada

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Table 1C (Page 1 of 1)

Spring/Seep
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Seep/Spring Location	Date Collected	Perchlorate 314.0	Anions 300M	TDS 160.1	Deuterium	Oxygen-18	Laboratory
SSSW03S02	MD509	S17	7/2/2003	X					DELMAR
SSSW03S02	ML509	S17	7/2/2003		X				DELMAR
SSSW03S02	ML509C	S17	7/2/2003	X					CEIMIC
SSSW03S02	MW509	S17	7/2/2003				X	X	WATERLOO
SSSW10S01	MD501	S13	7/1/2003	X					DELMAR
SSSW10S01	ML501	S13	7/1/2003		X	X			DELMAR
SSSW10S01	ML501C	S13	7/1/2003	X					CEIMIC
SSSW10S01	MW501	S13	7/1/2003				X	X	WATERLOO
SSSW11S01	MD502	S25	7/1/2003	X					DELMAR
SSSW11S01	ML502	S25	7/1/2003		X	X			DELMAR
SSSW11S01	ML502C	S25	7/1/2003	X					CEIMIC
SSSW11S01	MW502	S25	7/1/2003				X	X	WATERLOO
SSSW12S01	MD508	S30	7/2/2003	X					DELMAR
SSSW12S01	ML508	S30	7/2/2003		X				DELMAR
SSSW12S01	ML508C	S30	7/2/2003	X					CEIMIC
SSSW12S01	MW508	S30	7/2/2003				X	X	WATERLOO
SSSW13S01	MD510	S9	7/2/2003	X					DELMAR
SSSW13S01	ML510	S9	7/2/2003		X				DELMAR
SSSW13S01	ML510C	S9	7/2/2003	X					CEIMIC
SSSW13S01	MW510	S9	7/2/2003				X	X	WATERLOO
SSSW14S01	MD511	S10	7/2/2003	X					DELMAR
SSSW14S01	ML511	S10	7/2/2003		X				DELMAR
SSSW14S01	ML511C	S10	7/2/2003	X					CEIMIC
SSSW14S01	MW511	S10	7/2/2003				X	X	WATERLOO
SSSW15S01	ML604	S31	7/17/2003	X	X	X			DELMAR
SSSW15D01	ML607	S31	7/17/2003	X					DELMAR
SSSW15S01	MW604	S31	7/17/2003				X	X	WATERLOO
SSSW17S01	ML606	S33	7/17/2003	X	X	X			DELMAR
SSSW17S01	MW606	S33	7/17/2003				X	X	DELMAR

Notes:
Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)
This table lists all samples collected and all analyses requested during the sampling program.
Sample Identification = RFI site and sample identifier code
Lab Identification = Laboratory reporting code
Lab Identification Designators:

"MD" Prefix = Primary samples shipped directly to Del Mar Analytical
"ML" Prefix = Primary samples shipped to Del Mar Analytical by Ceimic.
Transferred by order of MWH following notification of lapse in Ceimic's California state certification.
"MW" Prefix = Primary sample aliquot analyzed for stable Hydrogen and Oxygen isotopes at University of Waterloo
"C" Suffix = Confirmation split sample analyzed at Ceimic

Anions = Alkalinity, Chloride, Sulfate
TDS = Total Dissolved Solids

Perchlorate Analytical Method:
USEPA Method 314.0 by Ion Chromatography (IC)

CEIMIC = Ceimic Corporation Laboratory, Narragansett, RI
DELMAR = Del Mar Analytical Laboratory, Irvine, CA
WATERLOO = University of Waterloo, Waterloo, Ontario, Canada

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Table 1D (Page 1 of 1)

Rock Chip
Analytical Summary
Northern Drainage

Sample Identification	Lab Identification	Seep/Spring Location	Date Collected	Perchlorate 314.0	Laboratory
ML622	SSRC01S01	S30	7/16/2003	X	DELMAR
MJ300	SSRC02S01	S33	7/17/2003	X	DELMAR

Notes:

Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)

This table lists all samples collected and all analyses requested during the sampling program.

ML622 = Field Leachate

Sample Identification = RFI site and sample identifier code

Lab Identification = Laboratory reporting code

Perchlorate Analytical Method:

USEPA Method 314.0 by Ion Chromatography (IC)

DELMAR = Del Mar Analytical Laboratory, Irvine, CA

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TABLE 2

SUMMARY OF DRAINAGE SEDIMENT SAMPLES

Sample Suffix ID	Number of Samples[(a)]	Sample Depth	General Sample Location
S01	76	From ground surface to ½" below surface	Within drainage
S02	11	From ½" below surface to 4" below surface	Within drainage
S03	12	6" above bedrock	Within drainage
S04	13	From ground surface to ½" below surface	Salt incrustation within bank of drainage
S05	1	From ground surface to ½" below surface	Over-bank of drainage
S06 – S11	10	Various depths below 4" from ground surface and more than 6" above top of bedrock	Within drainage
S90	2	"Original" leachate method using vertical composites	Within drainage
S99	15	"Original" leachate method using lateral composites, 6" below surface	Within drainage

(a) Based on sediment leachate samples summarized in Table 3 and shown on Plate 1; includes all duplicate and split samples.

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TABLE 3
SEDIMENT LEACHATE SAMPLING PERCHLORATE RESULTS
Northern Drainage

Sample Identification	Lab Identification	Sample Method	Date Sampled	Depth (ft bgs)	Analytical Method	Concentration	Units	Qualifier	Detection Limit
NDLS01S01	ML514	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS02S01	ML515	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS03D01	ML517	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS03S01	ML516	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS03S02	ML518	NL	7/8/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS03S03	ML519	NL	7/8/2003	4.0	E314.0	4.0	ug/l	U	4.0
NDLS03S06	ML535	NL	7/10/2003	1.75	E314.0	4.0	ug/l	U	4.0
NDLS03S09	ML536	NL	7/10/2003	2.5	E314.0	4.0	ug/l	U	4.0
NDLS03S11	ML537	NL	7/10/2003	3.5	E314.0	4.0	ug/l	U	4.0
NDLS03S90	MJ519	DV	7/24/2003	2.25	E314.0	4.0	ug/l	U	4.0
NDLS03S99	MJ516	DL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS04S01	ML520	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS04S04	ML524AP	NL	7/8/2003	0.04	E314.0	6.0	ug/l	UJ	6.0
NDLS04S04	MT146	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS05S01	ML521	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS06S01	MG633	NL	10/20/2003	0.04	8321	2.0	ug/l	U	2.0
NDLS06S01	ML522	NL	7/8/2003	0.04	E314.0	3.6	ug/l	J	4.0
NDLS06S01	MT147	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS07S01	ML523	NL	7/8/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS08S01	ML527	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS09S01	ML528	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS10S01	ML529	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS10S03	ML530	NL	7/9/2003	1.2	E314.0	4.0	ug/l	U	4.0
NDLS10S99	MJ529	DL	7/25/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS11S01	ML531	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS11S03	ML532	NL	7/9/2003	0.9	E314.0	4.0	ug/l	U	4.0
NDLS12S01	ML533	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS13S01	ML534	NL	7/9/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS14S01	MD540	NL	7/10/2003	0.04	E314.0	4.0	ug/l	UJ	4.0
NDLS14S02	ML541	NL	7/10/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS14S03	ML542	NL	7/10/2003	3.0	E314.0	4.0	ug/l	U	4.0
NDLS14S99	MJ540	DL	7/10/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS15S01	ML543	NL	7/10/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS16S01	ML544AP	NL	7/10/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS16S01	MT148	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS17S01	ML545	NL	7/10/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS17S02	ML546	NL	7/10/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS18S01	ML552	NL	7/10/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS18S02	ML553	NL	7/10/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS18S03	ML554	NL	7/10/2003	0.8	E314.0	4.0	ug/l	U	4.0
NDLS19S01	ML547	NL	7/10/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS19S02	ML548	NL	7/10/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS20S01	ML549	NL	7/10/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS22S01	ML555	NL	7/11/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS23S01	ML556	NL	7/11/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS24S01	ML557	NL	7/11/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS24S99	MJ557	DL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS25S01	ML558	NL	7/11/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS26S01	ML559AP	NL	7/14/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS26S01	MT150	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS27S01	ML560AP	NL	7/14/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS27S01	MT151	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS28S01	ML561AP	NL	7/14/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS28S01	MT152	NL	8/27/2003	0.04	E314.0	6.0	ug/l	U	3.0

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TABLE 3
SEDIMENT LEACHATE SAMPLING PERCHLORATE RESULTS
Northern Drainage

Sample Identification	Lab Identification	Sample Method	Date Sampled	Depth (ft bgs)	Analytical Method	Concentration	Units	Qualifier	Detection Limit
NDLS28S02	ML562	NL	7/14/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS29S01	ML563AP	NL	7/14/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS29S01	MT153	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS29S02	ML564	NL	7/14/2003	0.033	E314.0	4.0	ug/l	U	4.0
NDLS30S01	ML565	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS31S01	ML566	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS32S01	ML567	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS32S03	ML628	NL	7/24/2003	2.2	E314.0	4.0	ug/l	U	4.0
NDLS32D03	MJ568	NL	7/24/2003	2.2	E314.0	4.0	ug/l	U	4.0
NDLS32S99	MJ567	DL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS33S01	ML568	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS34S01	ML569	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS35S01	ML570AP	NL	7/14/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS35S01	MT154	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS36S05	MD571	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS36S99	MJ571	DL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS37S01	ML572	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS38S01	ML573	NL	7/14/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS39S01	ML576	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS40S01	ML577	NL	7/15/2003	0.04	E314.0	20.0	ug/l	UJ	20.0
NDLS40S01	MT155	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS41S01	ML578AP	NL	7/15/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS41S01	MT156	NL	8/27/2003	0.04	E314.0	15.0	ug/l	U	15.0
NDLS41S02	ML579	NL	7/15/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS42S01	ML580	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS43S01	ML581	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS44S01	ML582	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS44S04	ML583	NL	7/15/2003	0.04	E314.0	20.0	ug/l	U	20.0
NDLS44S04	MT157	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS45S01	ML584	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS46S01	ML585	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS46S99	MJ585	DL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS47S01	ML586	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS48S01	ML587	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS48S99	MJ587	DL	7/25/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS49S01	ML588	NL	7/15/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS50S01	ML589	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS51S01	ML590AP	NL	7/16/2003	0.04	E314.0	15.0	ug/l	UJ	15.0
NDLS51S01	MT159	NL	8/28/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS51S02	ML591	NL	7/16/2003	0.33	E314.0	4.0	ug/l	U	4.0
NDLS51S99	MJ590AP	DL	7/25/2003	0.5	E314.0	3.0	ug/l	UJ	3.0
NDLS51S99	MT160	DL	8/28/2003	0.5	E314.0	3.0	ug/l	U	3.0
NDLS52S01	ML592AP	NL	7/16/2003	0.04	E314.0	15.0	ug/l	UJ	15.0
NDLS52S01	MT161	NL	8/28/2003	0.04	E314.0	30.0	ug/l	U	30.0
NDLS52S99	MJ592	NL	7/25/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS53S01	ML593	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS53S04	ML594AP	NL	7/16/2003	0.04	E314.0	6.0	ug/l	UJ	6.0
NDLS53S04	MT162	NL	8/28/2003	0.04	8321	2.0	ug/l	UJ	2.0
NDLS53S99	MJ593	DL	7/25/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS54S01	ML595AP	NL	7/16/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS54S01	MT163	NL	8/28/2003	0.04	8321	2.0	ug/l	UJ	2.0
NDLS54S04	ML596AP	NL	7/16/2003	0.04	E314.0	6.0	ug/l	UJ	6.0
NDLS54S04	MT164	NL	8/28/2003	0.04	8321	2.0	ug/l	UJ	2.0
NDLS55S01	ML597	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0

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TABLE 3
SEDIMENT LEACHATE SAMPLING PERCHLORATE RESULTS
Northern Drainage

Sample Identification	Lab Identification	Sample Method	Date Sampled	Depth (ft bgs)	Analytical Method	Concentration	Units	Qualifier	Detection Limit
NDLS55S04	ML598AP	NL	7/16/2003	0.04	E314.0	6.0	ug/l	UJ	6.0
NDLS55S04	MT165	NL	8/28/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS55S06	ML610	NL	7/17/2003	1.0	E314.0	4.0	ug/l	U	4.0
NDLS55S08	ML611	NL	7/17/2003	3.0	E314.0	4.0	ug/l	U	4.0
NDLS55S90	MJ598	DV	7/25/2003	2.2	E314.0	4.0	ug/l	U	4.0
NDLS55S99	MJ297	DL	7/16/2003	0.5	E314.0	4.0	ug/l	UJ	4.0
NDLS56S01	ML599	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS56S03	ML612	NL	7/17/2003	4.5	E314.0	4.0	ug/l	U	4.0
NDLS56S04	ML600	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS56S06	ML613	NL	7/17/2003	0.8	E314.0	4.0	ug/l	U	4.0
NDLS56S99	MJ298	DL	7/16/2003	0.5	E314.0	4.0	ug/l	UJ	4.0
NDLS57S01	ML601AP	NL	7/16/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS57S01	MT166	NL	8/28/2003	0.04	E314.0	15.0	ug/l	U	15.0
NDLS57S03	ML614	NL	7/17/2003	4.6	E314.0	4.0	ug/l	U	4.0
NDLS57S04	ML602	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS57S06	ML615	NL	7/17/2003	1.3	E314.0	4.0	ug/l	U	4.0
NDLS57S08	ML616AP	NL	7/17/2003	3.2	E314.0	3.0	ug/l	UJ	3.0
NDLS57S08	MT167	NL	8/29/2003	3.2	E314.0	3.0	ug/l	U	3.0
NDLS57S99	MJ299	DL	7/16/2003	0.5	E314.0	4.0	ug/l	UJ	4.0
NDLS58S04	ML603	NL	7/16/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS59S01	ML550AP	NL	7/10/2003	0.04	E314.0	3.0	ug/l	UJ	3.0
NDLS59S01	MT158	NL	8/27/2003	0.04	E314.0	3.0	ug/l	U	3.0
NDLS60S03	ML617	NL	7/17/2003	3.5	E314.0	4.0	ug/l	U	4.0
NDLS60S07	ML618	NL	7/17/2003	2.0	E314.0	4.0	ug/l	U	4.0
NDLS61S01	ML619	NL	7/17/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS62S01	ML620	NL	7/17/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS63S01	ML621	NL	7/17/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS64S01	ML623	NL	7/24/2003	0.04	E314.0	4.0	ug/l	U	4.0
NDLS64S02	ML624	NL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS64S03	ML625	NL	7/24/2003	1.5	E314.0	4.0	ug/l	U	4.0
NDLS65S02	ML626	NL	7/24/2003	0.5	E314.0	4.0	ug/l	U	4.0
NDLS65S03	ML627	NL	7/24/2003	1.1	E314.0	4.0	ug/l	U	4.0

Notes:
Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)
Table includes only final data deemed usable through validation process.

Sample Identification = RFI site and sample identifier code
Lab Identification = Laboratory reporting code
bgs = below ground surface
ug/l = micrograms per liter

Qualifiers:
U = Not Detected
J = Estimated Value
UJ = Estimated Value less than reporting limit

Perchlorate Analytical Methods:
USEPA Method 314.0 by Ion Chromatography (IC)
USEPA Method 8321 by Liquid Chromatography Thermospray Tandem Mass Spectrometry (LC/MS/MS)

Sample Methods:
DL = Leachates from laterally composited soil samples using 'original' method of leachate preparation.

DV = Leachates from vertically composited soil samples using 'original' method of leachate preparation.

NL = Leachates prepared from discrete samples using 'enhanced' leachate preparation.

HDMSe00049560

TABLE 4
SURFACE WATER SAMPLING PERCHLORATE RESULTS
Northern Drainage

Sample Identification	Lab Identification	Date Sampled	Analytical Method	Concentration	Units	Qualifier	Detection Limit
NDSW03S01	MD503	7/1/2003	E314.0	4.0	ug/l	U	4.0
NDSW03S01	ML503C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
NDSW04S01	MD504	7/1/2003	E314.0	4.0	ug/l	U	4.0
NDSW04S01	ML504C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
NDSW05S01	MD505	7/1/2003	E314.0	4.0	ug/l	U	4.0
NDSW05S01	ML505C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
NDSW06S01	MD506	7/1/2003	E314.0	4.0	ug/l	U	4.0
NDSW06S01	ML506C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
NDSW07S01	ML507C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
NDSW08D01	ML539	7/10/2003	E314.0	4.0	ug/l	U	4.0
NDSW08S01	MD538	7/10/2003	E314.0	4.0	ug/l	U	4.0
NDSW09S01	MD574	7/15/2003	E314.0	4.0	ug/l	U	4.0
NDSW10S01	ML608	7/17/2003	E314.0	4.0	ug/l	U	4.0
NDSW11S01	ML609	7/17/2003	E314.0	4.0	ug/l	U	4.0

Notes:
Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)
Table includes only final data deemed usable through validation process.

Sample Identification = RFI site and sample identifier code
Lab Identification = Laboratory reporting code
ug/l = micrograms per liter

Qualifiers:
U = Not Detected
UJ = Estimated Value less than reporting limit

Perchlorate Analytical Method:
USEPA Method 314.0 by Ion Chromatography (IC)

HDMSe00049561

TABLE 5
DRAINAGE SPRING/SEEP SAMPLING PERCHLORATE RESULTS
Northern Drainage

Location	Sample Identification	Lab Identification	Date Sampled	Analytical Method	Concentration	Units	Qualifier	Detection Limit
S17	SSSW03S02	MD509	7/2/2003	E314.0	4.0	ug/l	U	4.0
S17	SSSW03S02	ML509C	7/2/2003	E314.0	1.0	ug/l	UJ	1.0
S13	SSSW10S01	MD501	7/1/2003	E314.0	4.0	ug/l	U	4.0
S13	SSSW10S01	ML501C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
S25	SSSW11S01	MD502	7/1/2003	E314.0	4.0	ug/l	U	4.0
S25	SSSW11S01	ML502C	7/1/2003	E314.0	1.0	ug/l	UJ	1.0
S30	SSSW12S01	MD508	7/2/2003	E314.0	4.0	ug/l	U	4.0
S30	SSSW12S01	ML508C	7/2/2003	E314.0	1.0	ug/l	UJ	1.0
S9	SSSW13S01	MD510	7/2/2003	E314.0	4.0	ug/l	U	4.0
S9	SSSW13S01	ML510C	7/2/2003	E314.0	1.0	ug/l	UJ	1.0
S10	SSSW14S01	MD511	7/2/2003	E314.0	4.0	ug/l	U	4.0
S10	SSSW14S01	ML511C	7/2/2003	E314.0	1.0	ug/l	UJ	1.0
S31	SSSW15D01	ML607	7/17/2003	E314.0	4.0	ug/l	U	4.0
S31	SSSW15S01	ML604	7/17/2003	E314.0	4.0	ug/l	U	4.0
S33	SSSW17S01	ML606	7/17/2003	E314.0	4.0	ug/l	U	4.0

Notes:

Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)

Table includes only final data deemed usable through validation process.

Sample Identification = RFI site and sample identifier code

Lab Identification = Laboratory reporting code

ug/l = micrograms per liter

Qualifiers:

U = Not Detected

UJ = Estimated Value less than reporting limit

Perchlorate Analytical Method:

USEPA Method 314.0 by Ion Chromatography (IC)

HDMSe00049562

TABLE 6
ROCK CHIP SAMPLING PERCHLORATE RESULTS
Northern Drainage

Location	Sample Identification	Lab Identification	Matrix	Date Sampled	Analytical Method	Concentration	Units	Qualifier	Detection Limit
S30	SSRC01S01	ML622	Field Leachate	7/16/2003	E314.0	4.0	ug/l	U	4.0
S33	SSRC02S01	MJ300	Rock Chip	7/17/2003	E314.0	0.041	mg/kg	U	0.041

Notes:

Includes co-located duplicate and split samples - does not include other QC samples (e.g., blanks)

Table includes only final data deemed usable through validation process.

Sample Identification = RFI site and sample identifier code

Lab Identification = Laboratory reporting code

ug/l = micrograms per liter

mg/kg = milligrams per kilogram

Qualifiers:

U = Not Detected

HDMSe00049563

TABLE 7
SURFACE WATER AND SPRING/SEEP SAMPLING
STABLE HYDROGEN AND OXYGEN ISOTOPES RESULTS
Northern and Eastern Drainages

Drainage Surface Water

Sample Identification	Lab Identification	Date Sampled	STABLE ISOTOPES	
			Deuterium (^{2}H) (d ^{2}H 0/00 VSMOW)	Oxygen-18 (^{18}O) (d ^{18}O 0/00 VSMOW)
NDSW03S01	MW503	07/01/03	-44.84	-6.81
NDSW03S01	MW503RE	07/01/03	-43.84	- -
NDSW04S01	MW504	07/01/03	-38.00	-5.46
NDSW04S01	MW504RE	07/01/03	-36.80	- -
NDSW05S01	MW505	07/01/03	-13.79	1.07
NDSW05S01	MW505RE	07/01/03	-13.90	- -
NDSW06S01	MW506	07/01/03	-43.85	-6.71
NDSW06S01	MW506RE	07/01/03	-44.35	- -
NDSW08S01	MW538	07/10/03	-28.44	-4.10
NDSW08S01	MW538RE	07/10/03	-27.54	-4.31
NDSW09S01	MW574	07/15/03	-20.87	-2.48
NDSW09S01	MW574RE	07/15/03	-20.47	-2.38

Drainage Spring/Seep

Spring/Seep Location	Sample Identification	Lab Identification	Date Sampled	STABLE ISOTOPES	
				Deuterium (^{2}H) (d ^{2}H 0/00 VSMOW)	Oxygen-18 (^{18}O) (d ^{18}O 0/00 VSMOW)
S17	SSSW03S02	MW509	07/02/03	-46.26	-7.42
S17	SSSW03S02	MW509RE	07/02/03	-45.62	- -
S13	SSSW10S01	MW501	07/01/03	-49.42	-7.25
S13	SSSW10S01	MW501RE	07/01/03	-48.62	- -
S25	SSSW11S01	MW502	07/01/03	-48.04	-7.32
S25	SSSW11S01	MW502RE	07/01/03	-46.94	-7.25
S30	SSSW12S01	MW508	07/02/03	-51.56	-7.85
S30	SSSW12S01	MW508RE	07/02/03	-52.51	- -
S09	SSSW13S01	MW510	07/02/03	-46.10	-7.59
S09	SSSW13S01	MW510RE	07/02/03	-47.00	-7.51
S10	SSSW14S01	MW511	07/02/03	-17.88	-1.30
S31	SSSW15S01	ML604	07/17/03	- -	-7.10
S31	SSSW15S01	ML604RE	07/17/03	- -	-7.18
S33	SSSW17S01	ML606	07/17/03	- -	-6.40

Notes:
a) Units for the
hydrogen and

b) Lab Identification numbers ending in "RE" represent laboratory confirmation runs.

c) Isotope analysis not performed on 3 surface samples (SW07, SW10, and SW11) due to limited sample volume.

TABLE 8
SURFACE WATER AND SPRINGS/SEEPS SAMPLING RESULTS
GENERAL MINERAL ANALYSIS
Northern and Eastern Drainages

Drainage Surface Water

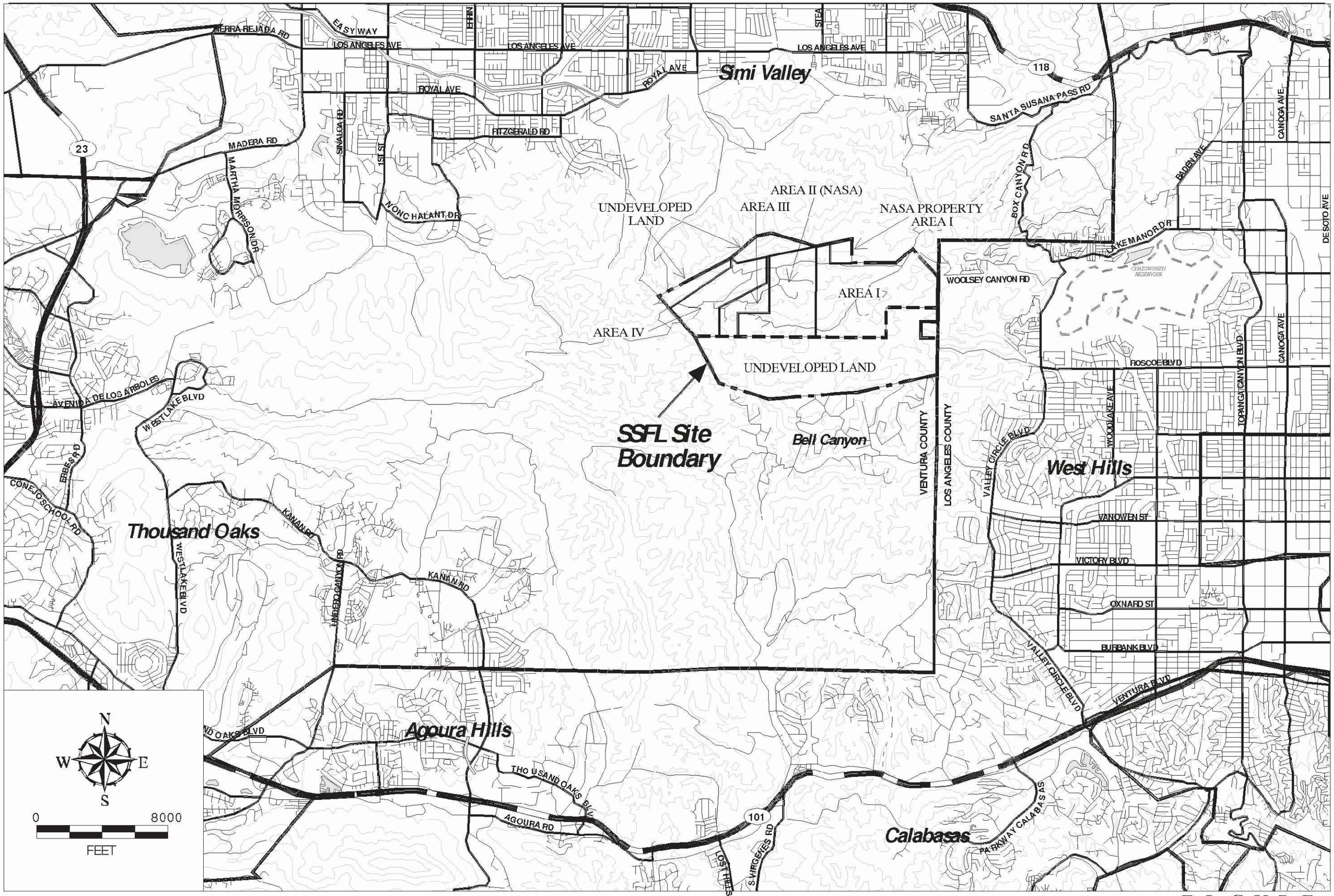
Sample Identification	Lab Identification	Date Sampled	Anion Concentrations (mg/L)					
			Chloride	Sulfate	Bicarbonate	Carbonate	Alkalinity	TDS
NDSW03S01	ML503	07/01/03	37	160	280	4.0	290	590
NDSW04S01	ML504	07/01/03	40	140	250	<2.0	250	550
NDSW05S01	ML505	07/01/03	120	290	250	<2.0	250	900
NDSW06S01	ML506	07/01/03	60	250	380	<2.0	380	890
NDSW08S01	ML551	07/10/03	7.3	7.9	62	<2.0	62	--
NDSW08D01	ML575	07/15/03	8.4	8.1	68	<2.0	68	--
NDSW09S01	ML574	07/15/03	6.4	6.7	46	<2.0	46	--

Drainage Spring/Seep

Spring/Seep Location	Sample Identification	Lab Identification	Date Sampled	Anion Concentrations (mg/L)					
				Chloride	Sulfate	Bicarbonate	Carbonate	Alkalinity	TDS
S17	SSSW03S02	ML509	07/02/03	25	99	220	<2.0	220	--
S13	SSSW10S01	ML501	07/01/03	46	240	1400	<2.0	1400	890
S25	SSSW11S01	ML502	07/01/03	38	160	280	<2.0	280	570
S30	SSSW12S01	ML508	07/02/03	21	110	300	4.0	300	--
S09	SSSW13S01	ML510	07/02/03	31	120	270	<2.0	270	--
S10	SSSW14S01	ML511	07/02/03	19	39	140	<2.0	140	--
S31	SSSW15S01	ML604	07/17/03	46	180	250	<2.0	250	590
S33	SSSW17S01	ML606	07/17/03	36	240	130	<2.0	130	550

Notes:
Table includes only final data deemed usable through validation process.
Alkalinity, Carbonate, and Bicarbonate concentrations reported as $CaCO_3$.
TDS = Total Disolved Solids

HDMSe00049565



FIGURE

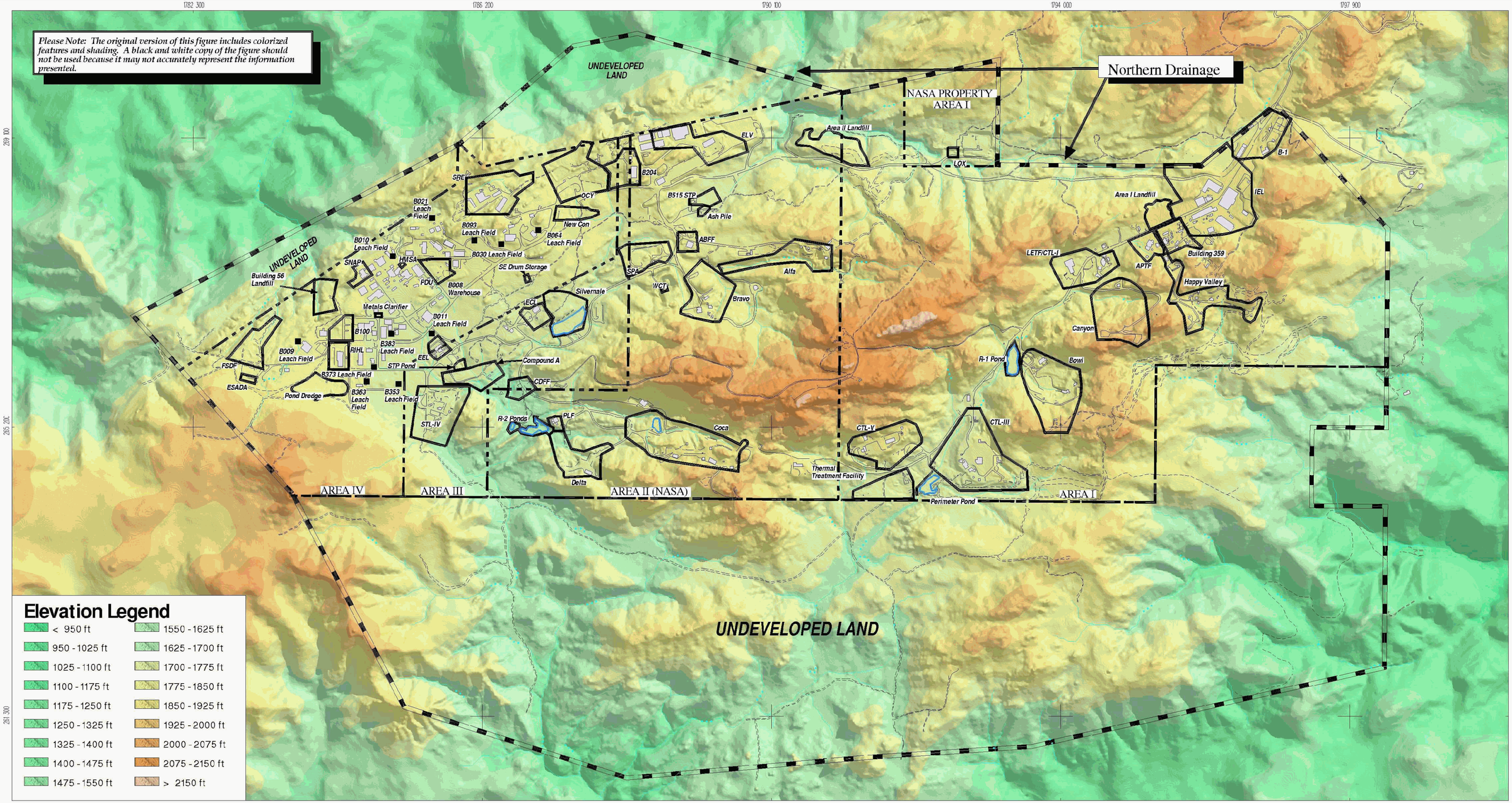
1

Regional Location Map
Santa Susana Field Laboratory

MWH
MONTGOMERY WATSON HARZA

/yap/rock/plots/figures/tcefigs_rfi_7.aml

HDMSe00049566



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FEET

MAP COORDINATES IN STATEPLANE, NAD 27, ZONE V.

RFI SITES

AREA I

SWMU 4.1 - B-1 Area
SWMU 4.2 - Area I Landfill
SWMUs 4.3, 4.4 and AOC - Instrument and Equipment Laboratories (IEL)
SWMU 4.5,4.6 - LOX Plant Former Sump/Clarifier and Drum Disposal Area
SWMU 4.7 - Component Test Laboratory III (CTL-III) Area
SWMU 4.8 - Thermal Treatment Facility (TTF) RCRA Permitted Unit
SWMU 4.9, AOC - Advanced Propulsion Test Facility (APTF) Area
SWMU 4.12 - Laser Engineering Test Facility (LETF)/Component Test Lab I (CTL-I) Area
SWMU 4.14 - Canyon Area
SWMU 4.15 and AOC - Bowl Area and Building 901 Leachfield
SWMU 4.16 - Area I Reservoir (R-1 Pond)
SWMU 4.17 - Perimeter Pond

AREA I (cont)
AOC - Building 359 Sump
AOC - Happy Valley Area
AOC - Component Test Laboratory V (CTL-V)

AREA II

SWMU 5.1 - Area II Landfill
SWMU 5.2 - ELV Final Assembly, Building 206
SWMU 5.5 and AOC - Building 204 Area
SWMU 5.6 - Former Incinerator Ash Pile
SWMU 5.7 - Hazardous Waste Storage Area Waste Coolant Tank (WCT)
SWMUs 5.9, 5.10, 5.11 - Alfa Area
SWMUs 5.12, 5.13, 5.14, 5.15 - Alfa/Bravo Skim Pond and Bravo Area
SWMUs 5.18, 5.19 - Coca Area
SWMUs 5.20, 5.21, 5.22 - Propellant Load Facility (PLF)
SWMU 5.23 - Delta Area

AREA II (cont)
SWMU 5.26 - R-2A and R-2B Ponds
AOC - Building 515 Sewage Treatment Plant
AOC - Storable Propellant Area (SPA)
AOC - Alfa/Bravo Fuel Farm
AOC - Coca/Delta Fuel Farm

AREA III

SWMUs 6.1, 6.3, AOC - Engineering Chemistry Laboratory (ECL) Area
SWMU 6.4 - Compound A Facility
SWMU 6.5 - Systems Test Laboratory IV (STL-IV) Area
SWMU 6.8 - Silvernale Reservoir
SWMU 6.9 - Environmental Effects Laboratory (EEL)
AOC - Sewage Treatment Plant (STP) Pond Area

AREA IV
SWMU 7.1 - Building 56 Landfill
SWMU 7.3 - Former Sodium Disposal Facility (FSDF)
SWMU 7.4 - Old Conservation Yard (OCY)
SWMU 7.5 - Building 100 Trench
SWMU 7.7 - Rockwell International Hot Laboratory (RIHL)
SWMU 7.8 - New Conservation Yard (New Con)
SWMU 7.9 - ESADA Chemical Storage Area
SWMU 7.10 - Former Coal Gasification PDU
AOC - Former Hazardous Materials Storage Area (HMSA)
AOC - Chemistry Laboratory Metals Clarifier
AOC - Pond Dredge Area
AOC - Sodium Reactor Experiment (SRE) Area
AOC - SE Drum Storage Yard
AOC - SNAP Facility

Basemap Legend

Buildings
SSFL Property Boundary
Administrative Area Boundary
RFI Site Boundary
Drainages
Ponds
Contours
Dirt Roads
Roads
Leach Fields

RFI Site Locations
Santa Susana
Field Laboratory

SANTA SUSANA FIELD LABORATORY

DATE: 11/16/03
FILE: rocke/pkoc/figures/rfi_location.aml

MWH

FIGURE 2

HDMSe00049567

FILE: CAD MLUEBKE\BOEING\SANTA SUSANA\PERCHLORATE INVESTIGATION 7 21 03\DRAINAGE FIGURES 8 13 03

JOB No.

Please Note: The original version of this figure includes colorized features and shading. A black and white copy of this figure should not be used because it may not accurately represent the information presented.

OS-9

Eastern Drainage of SSFL
(832 Acres)

Northern Drainage of SSFL
(778 Acres)

Undeveloped Land

Area II

Area IV

Area III

Area I

Area I
Landfill

Bldg 359
RFI Site

Undeveloped Land

Undeveloped Land

Burro Flats

Runkle Canyon

Runkle Res

Meier Canyon

Dayton

Woolsey

Santa Susana
County Park

Legend

- SSFL Property Boundary
- Area Boundary
- Streams/Drainages of Interest
- Flowing Artesian Well
- RFI Site Boundary of Primary Perchlorate Use Area
- Drainage Divide

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SCALE

Base Map Taken from TOPO Wildflower Topo Series (2000)

MWH

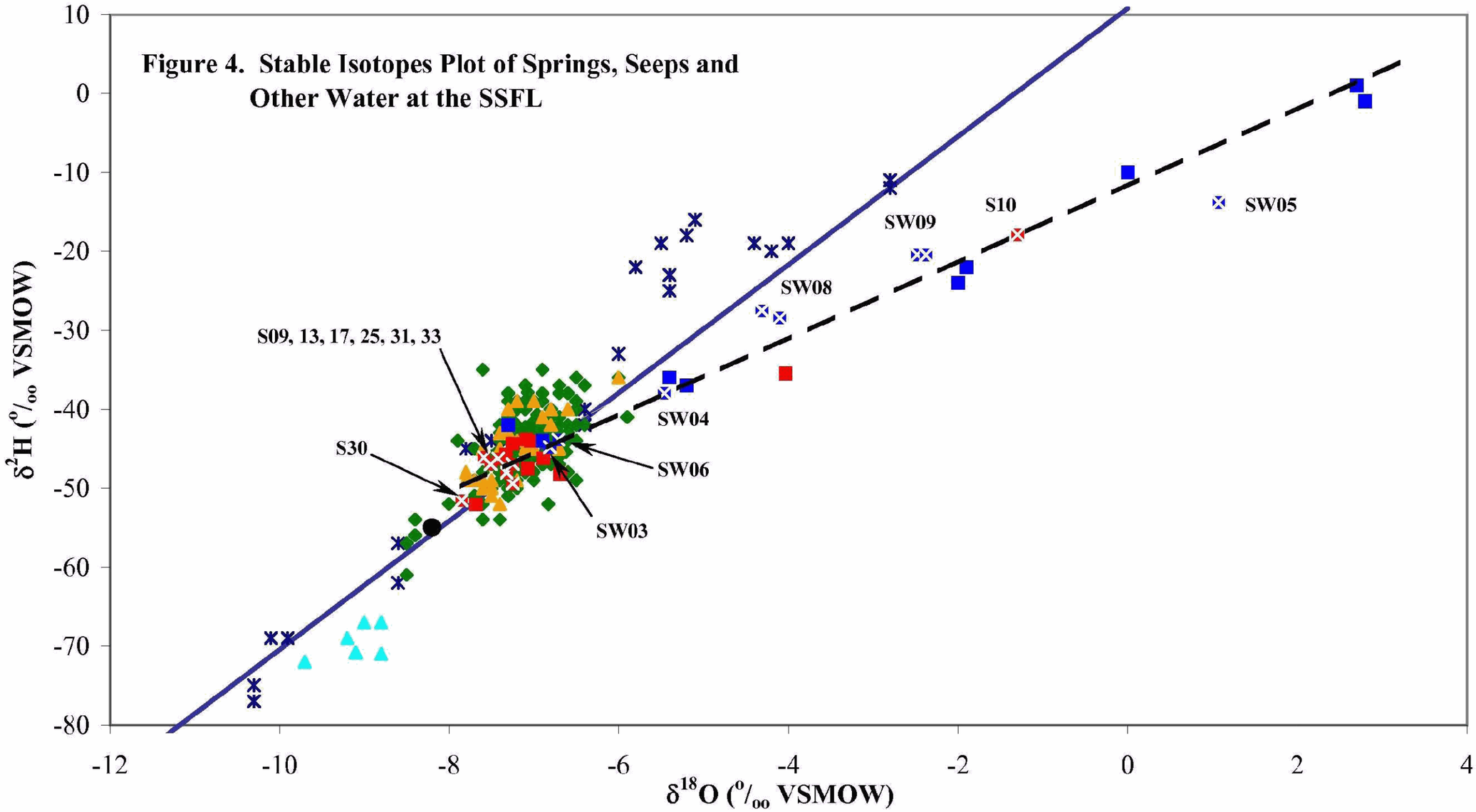
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA
AUGUST 2003

CATCHMENT AREAS OF THE NORTHERN AND EASTERN DRAINAGES

FIGURE 3

HDMSe00049568

Figure 4. Stable Isotopes Plot of Springs, Seeps and Other Water at the SSFL



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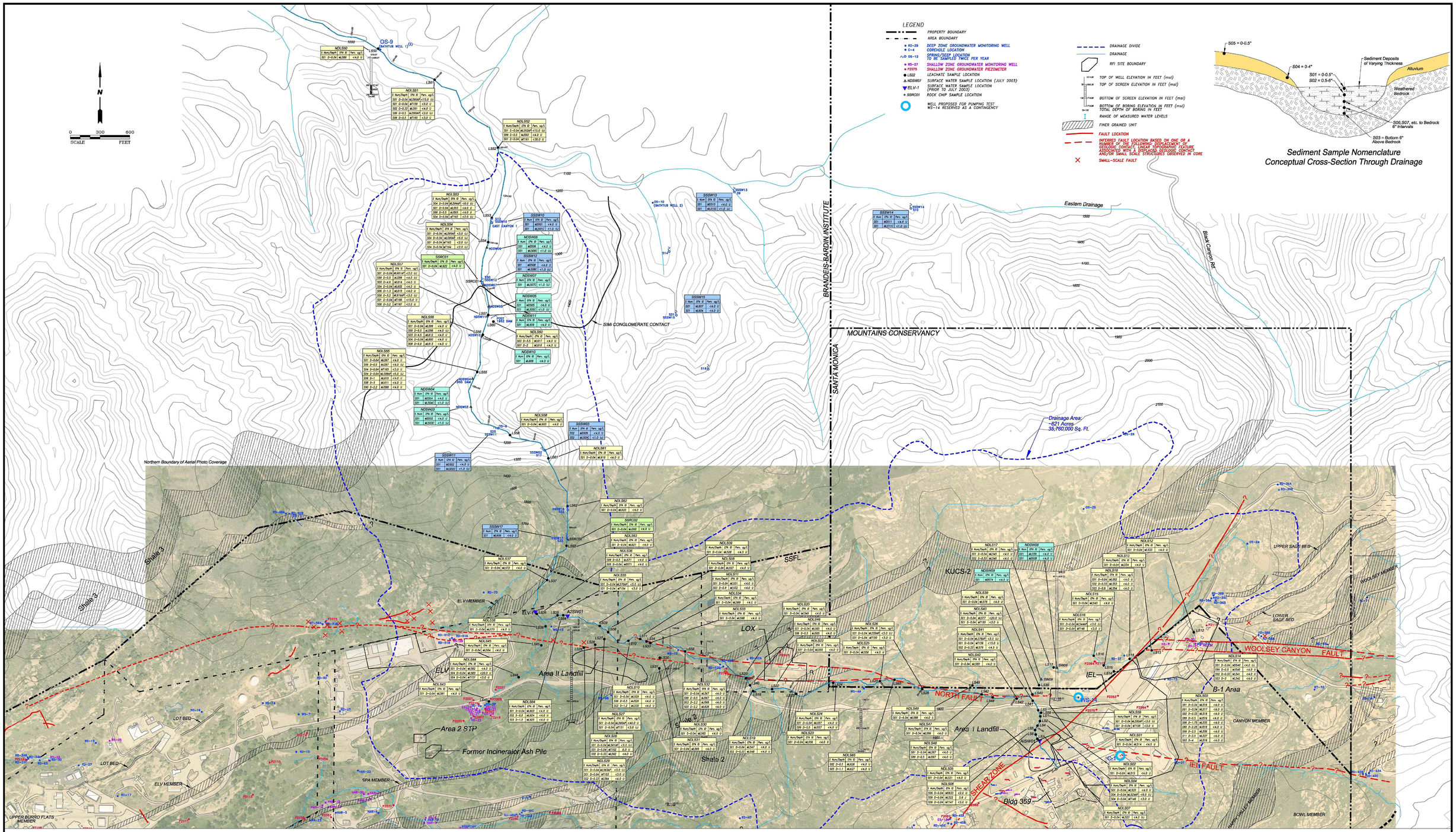
LEGEND
PROPERTY BOUNDARY
AREA BOUNDARY
RD-29 DEEP ZONE GROUNDWATER MONITORING WELL
C-4 COREHOLE LOCATION
OS-12 SPRING/SEEP LOCATION TO BE SAMPLED TWICE PER YEAR
RS-27 SHALLOW ZONE GROUNDWATER MONITORING WELL
P207R SHALLOW ZONE GROUNDWATER PIEZOMETER
LS22 LEACHATE SAMPLE LOCATION
NDSW07 SURFACE WATER SAMPLE LOCATION (JULY 2003)
ELV-1 SURFACE WATER SAMPLE LOCATION (PRIOR TO JULY 2003)
SSRC01 ROCK CHIP SAMPLE LOCATION
WELL PROPOSED FOR PUMPING TEST WS-14 RESERVED AS A CONTINGENCY
DRAINAGE DIVIDE
DRAINAGE
RFI SITE BOUNDARY
TOP OF WELL ELEVATION IN FEET (msl)
TOP OF SCREEN ELEVATION IN FEET (msl)
BOTTOM OF SCREEN ELEVATION IN FEET (msl)
BOTTOM OF BORING ELEVATION IN FEET (msl) TOTAL DEPTH OF BORING IN FEET
RANGE OF MEASURED WATER LEVELS
FINER GRAINED UNIT
FAULT LOCATION
INFERRED FAULT LOCATION BASED ON ONE OR A NUMBER OF THE FOLLOWING: DISPLACEMENT OF GEOLOGIC CONTACT, LINEAR TOPOGRAPHIC FEATURE, ASSOCIATED WITH A DISPLACED GEOLOGIC CONTACT AND/OR SMALL SCALE STRUCTURES OBSERVED IN CORE
SMALL-SCALE FAULT
S05 = 0-0.5'
S04 = 0-4"
S01 = 0-0.5"
S02 = 0.5-6"
Sediment Deposits of Varying Thickness
Alluvium
Weathered Bedrock
S06,S07, etc. to Bedrock 6" Intervals
S03 = Bottom 6" Above Bedrock
Sediment Sample Nomenclature
Conceptual Cross-Section Through Drainage
N
0 300 600
SCALE FEET
OS-9 (BATHTUB WELL 1)
LS20
LS21
LS01
LS22
LS23
LS24
LS25
LS26
LS27
LS28
LS29
LS30
LS31
LS32
LS33
LS34
LS35
LS36
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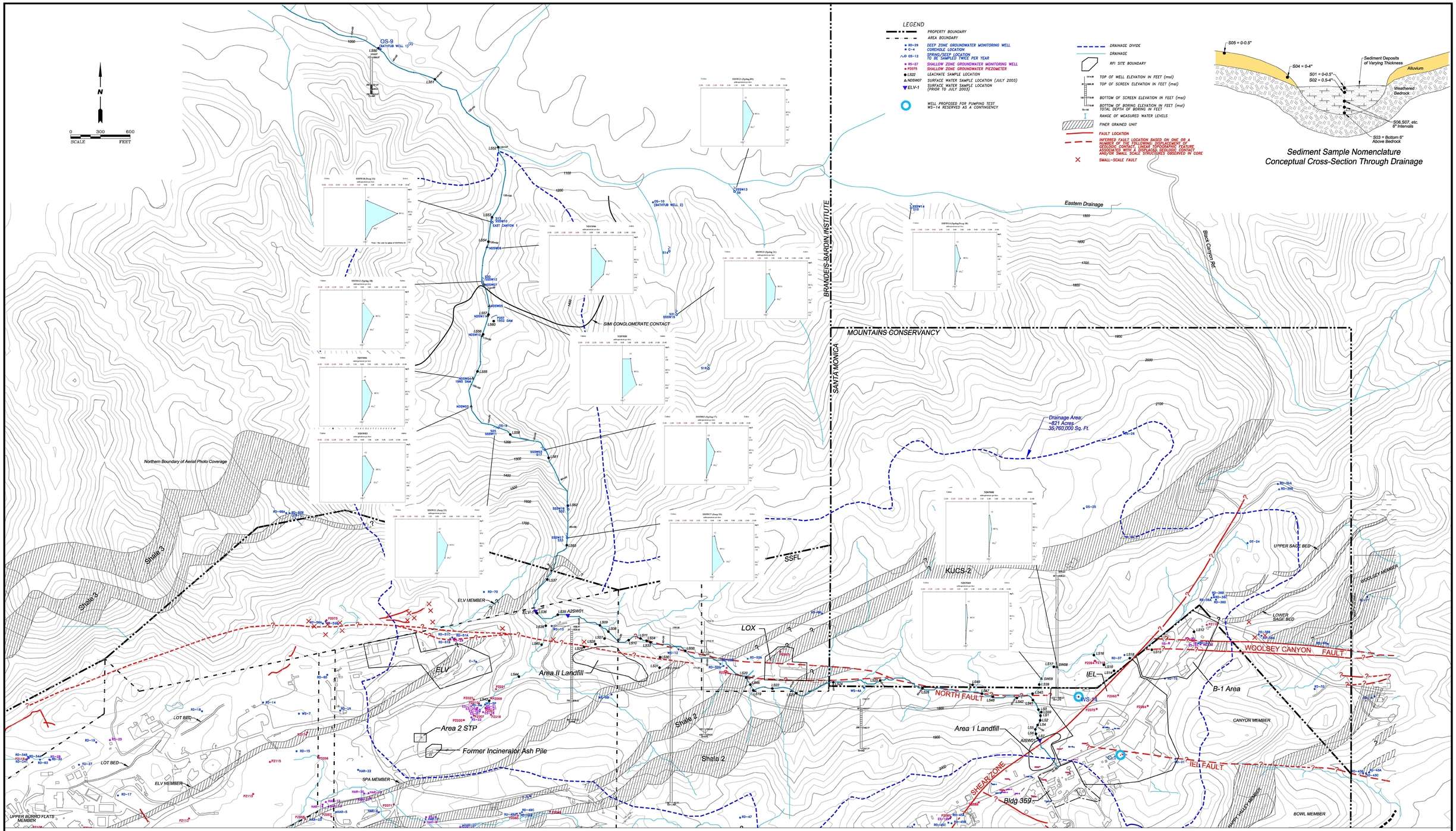
LS60
LS61



HDMSe00049571